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## Editorial

1947

THIS marks the twentieth time we have extended New Year's greetings to our subscribers. When we typed our first editorial in 1927 the country was on a protracted prosperity binge. The hangover and headache began late in 1929 and continued for several years. Just as things were reaching a sane and normal level Hitler and his gangsters touched off the powder-keg of war and the long nightmare began. This was followed by Pearl Harbor, and we were in the conflict up to our necks. In a thousand details our lives were changed. Medical colleges went on a three-year accelerated program. Medical teachers forewent the usual summer vacations and worked in the classroom and laboratory twelve months a year. Teaching and hospital staffs were depleted by our young men joining up with the armed forces; there was an acute nursing shortage. Interns were allowed a year's training; residents of quality were as scarce as hen's teeth. The war ended and we were lulled into a rosy complacency by wishful thinking. Now, everything was going to be all right, and in no time we would be back to the old life of normalcy (coined after World War I), ease and plenty.

Instead life has been a mess. The boys who were in uniform came back and suddenly it was realized there were not

sufficient internships and residencies available for those equipped and trained to fill them. The nursing shortage became worse. Hospital costs (along with all other costs) soared, and illness became unduly expensive. The white collar worker suffered (and still suffers) because of this economic disruption. There has been a rash of strikes, some justified, many unfair and unnecessary. The physician, three or four years in service, returned to civilian life and discovered he could not find a home to live in or an office in which to practice. These conditions persist at this writing. (We are just now concerned with the current coal strike). Specialists in world affairs warn us there is trouble ahead. Times might not be too good. Stop! Look! Listen!

Meanwhile, organized medicine has done a good job. Its war record is something to point to with pride and satisfaction. This goes for those in uniform and for those who remained at home. Surgery has not stood still. We learned many lessons, especially in bone surgery from the war, but civilian medicine also made great strides. In surgery the astounding advances in cardiac surgery and the newer operations for the treatment of extensive cicatricial obliteration of the esophagus, which we give as examples, make one wonder what marvels



are in store in the near future. The sulfa drugs, penicillin and the possibilities of streptomycin have changed the morbidity and mortality curve in all branches of medicine.

We hope, and we know all of us hope, that 1947 will be a year in which we rapidly get back on a normal foundation. We hope costs come down and the expense of illness will be reduced; that hospitals will be able to reduce charges, be able to afford to "do over" or expand their plants, and that somehow sufficient trained nurses will be available to care properly for the civilian sick. We hope the young man recently in uniform will be able to complete his training and in time be eligible to take his Board examinations. The various American Boards have done good work; they have kept their standards high and have the respect of the profession at large.

From a personal angle we know the material in this Journal in the months to come will be of a high quality. It seems only yesterday that we went through the nightmare of wondering whether or not

we would receive enough good material for an issue every month. Now we note a great increase of articles submitted for publication and that the great majority of them are excellent. We believe our editorial worries from now on will be minor ones. American surgical literature has been kept on a high plane in spite of adverse conditions. This goes for our competitors. We do not think ours is the only and best journal in every respect. Every month we read with profit and pleasure *The American Journal of Obstetrics and Gynecology*, *Annals of Surgery*, and *Surgery, Gynecology and Obstetrics*. We feel all of us have and serve a certain field, and do it well.

Wishful thinking or no—we hope socialized medicine will be filed alongside of the Dodo bird during 1947, that we quickly get back to a peaceful, productive, prosperous, normal life, and that the coming year will mark the beginning of an era of good living.

To you one and all we wish a healthy and contented 1947.

T. S. W.



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# Original Articles

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## WAR WOUNDS OF THE VENTRICLES OF THE BRAIN

LIEUT. COL. WM. R. PITTS

MEDICAL CORPS, ARMY OF THE UNITED STATES

REPORTS concerning wounds of the ventricles of the brain from World War I emphasized the high mortality rate. The high fatality rate was attributed, for the most part, to the lack of a barrier against infection once the missile traversed the ventricular system and also the ease with which any introduced infection may be quickly disseminated by the circulating C. S. F. It was with reservation, therefore, that we approached wounds of the ventricles in this war with our spirits bolstered, fully expecting excessive fatalities. Although infection still claims its toll, certainly in this war its dangers have been reduced by improved therapeutic measures.

This report deals with penetrating wounds of the cerebral ventricular system as seen and treated in an Evacuation hospital. Realizing full well that conclusions drawn from a small group of cases without adequate information concerning end results is apt to be misleading, we wish to present the picture of this problem as seen in the forward area where the first definitive surgery for brain wounds is carried out. (Table I.)

TABLE I

I. Number of Battle Casualties (15 October 1942 to 10 March 1945).....	10,455
II. Number of Penetrating Wounds of Brain..	108
Incidence 1.03%	
III. Number of Penetrating Wounds of Brain with Involvement of Ventricles.....	16
Incidence 14.8%	

During the Italian campaign from October 15, 1943, to March 10, 1945, 10,455 battle casualties were admitted to an Evacuation hospital. Among this group there were 108 penetrating wounds of the

brain, giving an incidence of 1.03 per cent. In this group of penetrating wounds of the brain the ventricles were implicated in sixteen cases, an incidence of 14.8 per cent.

For the purpose of description and analysis the cases of this report may be divided into two groups. Group one is composed of those patients who were admitted in a moribund state and died without surgery, and group two represents those who survived long enough to undergo surgery. There were three patients in group one and thirteen in group two. The fact that there were so few, comparatively speaking, in group one is strong evidence that many others did not survive long enough to reach the evacuation area. In fact, many such wounds no doubt led to battlefield fatalities. The picture presented by the cases of group one can best be shown by reviewing in brief the principal features in each.

CASE I. Patient had perforating wound of the head from shell fragment, right occipital to left frontal, coma, stertorous respiration, pulse 140, blood pressure 140/0, respiration 36, right pupil dilated and fixed, left pupil contracted and fixed, all four extremities spastic with bilateral pyramidal tract signs, decerebrate extensor spasms at forty-five-second intervals, finally flaccidity and death four hours after admission. Postmortem examination showed tract to extend from right occipital lobe to left frontal lobe, traversing right lateral ventricle, thalamus and left lateral ventricle. Both lateral ventricles were filled with hematomas forming a cast of the lateral ventricles. A pressure cone was present.

CASE II. Patient had perforating gunshot wound of head, right temporal to left parietal region, coma, stertorous respirations, decere-

brate extensor spasms, blood pressure 60/7, pulse 140, respirations 36, right pupil dilated and fixed. Death occurred ten hours after wounding. Autopsy revealed missile tract extending from lower border, right Sylvian fissure to left parietal region traversing the right lateral ventricle, septum lucidum and left lateral ventricle. The right cerebral hemisphere was markedly swollen throughout. The tract was filled with numerous blood clots and fragments of bone and was surrounded by wide zone of pulped brain. Both lateral ventricles contained numerous blood clots in the vicinity of the tract. Section of pons and medulla revealed no hemorrhages.

TABLE II-A  
PERTINENT FEATURES OF CASES OF GROUP I

Case	Survival Period	State of Consciousness	State of Pupils	State of Musculature
1.	4 hr. After Admission	Coma	Right Dilated and fixed. Left Contracted and Fixed	Decerebrate Extensor Spasm
2.	10 hr.	Coma	Right Dilated and Fixed	Decerebrate Extensor Spasm
3.	10 hr.	Coma	Right Dilated and Fixed	Flaccidity All 4 Extremities

CASE III. Patient had penetrating gunshot wound of head, left eye to left parietal region, coma, irregular stertorous respirations, blood pressure 138/78, pulse 128, respirations 40. All four extremities flaccid with areflexia. Right pupil dilated and fixed; the left globe was collapsed. Death occurred ten hours after injury. Autopsy revealed tract of missile passing through roof of left orbit penetrating inferior medial surface of left frontal lobe to traverse the left lateral ventricle and left parietal lobe. The bullet was found impacted in parietal bone just to left of mid-line 11 cm. above the inion. A 75 cc. collection of blood was found in the left subdural space. The left lateral ventricle contained only a few small blood clots. A definite pressure cone was present. (Table II A.)

*Comment.* The representative picture exemplified by the cases in Group 1, therefore, is a deeply comatose patient with rapid stertorous respirations, rapid pulse, and wide pulse pressure. Tables II A and II B show the pertinent common features of these cases. The survival period was ten hours in two cases and four hours in one. Unilateral pupillary dilatation was present in all cases. Decerebrate extensor spasm was present in two cases and flaccidity in one case. (Table II B.) The ventricular wound was a perforating wound in all cases and in two a perforating wound of both lateral ventricles was present. Intra-ventricular hematomas were massive in two cases and in all cases there was extensive masseration of brain tissue for a wide zone surrounding the tract of the missile.

TABLE II-B  
PERTINENT FEATURES OF CASES OF GROUP I

Case	Pulse	B P	Resp	Ventricular Wound	Pathology
1	140	110/0	36	Bilateral Ventricular Wound Thalamic Wound	Massive Bilateral Brain Damage. Pressure Cone. Massive Intra-ventricular Hematoma
2.	140	60/7	36	Bilateral Perforating Wound of Lateral Ventricles	Wide Zone of Pulped Brain about Tract. Blood Clots in Both Lateral Ventricles
3	128	118/70	40	Perforating Wound Left Lateral Ventricle	5 Cm Zone of Pulped Brain Surrounding Tract Pressure Cone

The second group of cases to be analyzed in this report is comprised of thirteen patients with ventricle wounds who survived a sufficient length of time to permit surgery. Although this group did not present any characteristic syndrome by which it may be recognized or distinguished from the ordinary severe penetrating wound of the brain, however, there were several features which were fairly constant in the majority. All were rendered unconscious immediately and the duration of unconsciousness varied from thirty minutes

to five days. The period of unconsciousness was unknown in six instances. It may be seen from Table III that two patients were unconscious for thirty minutes and there were periods of unconsciousness of six, nine and twelve hours in single instances. One patient was unconscious for five days and another remained unconscious from the time of wounding until death four days later. The mental status of these patients on admission showed considerable variation. (Table IV.) Four cases were comatose and quiet, four were stuporous and quiet, two were stuporous and irritable and three patients were drowsy and confused. (Table V.) Two of the comatose patients of group two had large hematomas within the missile tract, one had a penetrating wound of the ventricle with laceration of the corpus callosum, and another had massive brain damage bilaterally with a perforating wound of both lateral ventricles.

TABLE III

DURATION OF UNCONSCIOUS PERIOD

Unknown.....	6 Cases
30 Min.....	2 Cases
6 Hrs.....	1 Case
9 Hrs.....	1 Case
12 Hrs.....	1 Case
4 Days.....	1 Case (Continuous from Injury to Death)
5 Days.....	1 Case

TABLE IV

MENTAL STATUS OF GROUP II PATIENTS ON ADMISSION TO HOSPITAL

Comatose and Quiet.....	4 Cases
Stuporous and Quiet.....	4 Cases
Stuporous and Irritable.....	2 Cases
Drowsy and Confused.....	3 Cases

Analysis of the vital signs revealed that nine of the thirteen patients of this group showed a moderately widened pulse pressure, the average being 48 mm. of mercury. A wide pulse pressure *per se* did not bear a uniform relationship to increased intracranial pressure, there being only six patients with a wide pulse pressure and a tight brain while five others with a wide pulse pressure had a relaxed brain. On the other hand, bradycardia was present in only two of the thirteen operative cases and on both occasions was associated with

a massive intraventricular or intracerebral hematoma, or both. The bradycardia in both instances was combined with a wide pulse pressure and a tight brain. The respiratory rate of all patients in this group was within normal limits except for two. One patient with a respiratory rate ranging from 40 to 50 per minute had perforating wounds of both lateral ventricles while another with a respiratory rate of 12 had a penetrating wound of the left lateral ventricle with massive laceration of the corpus collosum.

TABLE V

PATHOLOGY OF COMATOSE PATIENTS IN GROUP II

State of Consciousness	Pathology
Comatose.....	Large Hematoma in Tract
Comatose.....	Large Hematoma in Tract
Comatose.....	Penetrating Wound of Ventricle with Laceration of Corpus Callosum
Comatose.....	Massive Brain Damage, Bilaterally, with Perforating Wound of Both

Lateral Ventricles

TABLE VI

Local Signs	Cases	Location of Wounds
Homonomous Hemianopsia.....	2	Occipital
Homonomous Hemianopsia and Hemiparesis.....	1	Parieto-Occipital
Decerebrate Rigidity.....	1	Right Frontal to Left Occipital
Triplegia.....	1	Oblique Parasagittal, Parietal
Hemiparesis.....	1	Temporal
Hemiparesis.....	1	Right Frontal to Left Parietal
Hemiparesis.....	2	Parietal
None.....	3	Frontal
None.....	1	Occipital
Total.....	13	

Localizing neurological signs were of no aid in predicting implication of the ventricles preoperatively in as much as they uniformly represented local brain damage produced by the missile. (Table VI.) It may be seen from Table VI that two occipital wounds resulted in a homonomous hemianopsia, one parieto-occipital wound produced a hemianopsia associated with a

hemiparesis. Decerebrate rigidity was present in one case as the result of a tract extending from the right frontal to the left occipital region, triplegia was the resultant of an oblique parasagittal wound in the parietal area, hemiparesis was present in two cases due to parietal wounds, in one case due to a temporal wound, and in another hemiparesis was associated with a tract extending from the right frontal lobe to the left parietal region. In passing it might be said that the offending missile was a shell fragment in eleven cases, a bullet in one, and a mine fragment in another.

Only in one case was there a sufficient amount of cerebrospinal fluid drainage from the wound to point to the diagnosis of a wound of the ventricle. We realize full well that the course of a missile, once it has entered the body, is notoriously unpredictable and that the predicted trajectory is perhaps even more unreliable when the missile enters such a small bony box as the intracranial cavity which is bisected by the falx. None the less, in six cases it seemed fairly reasonable to make a presumptive diagnosis of a ventricular wound by considering the location of the wound of entrance in conjunction with the location of the missile and bone fragments as seen by x-ray.

*Anesthesia.* Nine of the thirteen operations were done under local anesthesia (1 per cent novocaine) with preoperative administration of morphine sulfate, gr.  $\frac{1}{6}$ . Four operations were done under local anesthesia supplemented by small amounts of pentothal sodium and in these cases the preoperative medication included atropine sulfate gr.  $\frac{1}{150}$ , as well as morphine sulfate, gr.  $\frac{1}{6}$ . The amount of pentothal used varied from 0.5 to 1.5 Gm. We were particularly impressed by the rather small amount of pentothal which was needed in order to convert a restless, irritable, straining, uncooperative patient to a quiet, peaceful state. Pentothal was chosen to supplement the local anesthesia because of its quick action, rapid elimination and the

fact that it does not increase intracranial pressure.

TABLE VII  
ANALYSIS OF 8 CASES WITH TIGHT BRAIN  
State of  
Consciousness

Pathological Findings	State of Consciousness
Laceration Corpus Callosum. Penetrating Wound of Left Lateral Ventricle.....	Coma
Large Hematoma in Tract. Small Hematoma in Ventricle.....	Coma
Large Hematoma in Tract. Small Hematoma in Ventricle.....	Coma
Small Hematoma in Ventricle.....	Stuporous and irritable
Large Hematoma in Tract. Small Hematoma in Ventricle.	Stuporous and Quiet
Penetrating Wound of Ventricle...	Semistuporous and Quiet
Small Hematoma in Ventricle.....	Stuporous and Quiet
Massive Hematoma in Ventricle. Large Hematoma in Tract.	Drowsy, Quiet and Confused

*Operative Findings.* In this series of cases only the lateral ventricles were implicated. There were eight penetrating and five perforating wounds of the ventricles. Bilateral brain damage was associated with these lesions in five instances and in one case there was also extensive damage of the corpus callosum. In only one instance was there a perforating wound of both lateral ventricles and this wound resulted in a fatality. No metallic foreign bodies were found within the confines of the ventricular cavities, however, in seven of the thirteen operative cases bone fragments were found lying loose in the ventricles. Needless to say, in all cases there was extensive damage to both the gray and the white matter of the brain. Increased intracranial tension, as determined by a tight brain at the time of operation, was present in eight of the thirteen cases in this group. The pathological findings in these eight cases of tight brain are correlated with the state of consciousness of the patient by Table VII. It is noted that in four instances the increased intracranial pressure or tight brain may be explained on the basis of a space taking lesion, that is to say, a large intraventricular or intracerebral hematoma. Paradoxically, the only patient

of this group of eight, who was not comatose or stuporous, had a massive intraventricular and intracerebral clot. Two of the remaining three patients with space occupying lesions were comatose and the third was stuporous.

*Operative Treatment.* The primary aim in the operative treatment of wounds of the ventricles is the same as in any penetrating wound of the brain, namely, surgical cleansing of the tract of the projectile by the removal of damaged tissue and of any foreign material which is not too deeply imbedded. Careful, gentle, thorough débridement of the wound from the scalp to the depth of the tract cannot be too strongly emphasized. In dealing with a wound suspected of implicating the ventricle it is well to keep irrigation to a minimum in the early stages of the débridement lest blood clots, small bone fragments, and débris be washed to a distant and inaccessible portion of the ventricle. It is also necessary to be extremely meticulous about complete hemostasis in the presence of a ventricular wound because of the added danger of postoperative hematomas due to the existing cavity which may act as a reservoir. In these wounds firm closure is also of the utmost importance in order to obviate the danger of the laking of cerebrospinal fluid in the subgaleal region or the formation of a cerebrospinal fluid leak. In an effort to obtain water tight closures it was necessary to use living fascial or periosteal grafts in eleven of the thirteen operative cases. In all cases the scalp was closed in two layers with interrupted sutures of either fine silk or cotton depending upon available supply.

TABLE VIII

## LOCAL CHEMOTHERAPY AT TIME OF OPERATION

10,000 Units Penicillin in Ventricle.....	8 Cases
20,000 Units Penicillin in Ventricle.....	1 Case
Sulfanilamide in Brain Tract.....	4 Cases

*Chemotherapy.* Some form of bacteriostatic agent was applied locally to the brain wounds of all operative cases at the conclusion of the procedure just prior

to the closing of the dura. (Table VIII.) Ten thousand units of penicillin were placed in the open ventricle on eight occasions and in one case 20,000 units of penicillin were instilled in the ventricle. In four cases the cerebral tract was treated with a generous dusting of sulfanilamide powder. All patients who came to operation were given systemic chemotherapy in one form or another. (Table IX.) In general

TABLE IX

## SYSTEMIC CHEMOTHERAPY POSTOPERATIVELY

Sulfadiazine by Mouth or Intravenously, (Gm. I, Q 4 H, After Initial Dose of Gm. IV). . . . .	9 Cases
Intramuscular Penicillin, Units 25,000 Q 3 H, and Penicillin, Units 10,000 Intrathecally Daily.....	3 Cases
Intramuscular Penicillin, Units 25,000 Q 3 H, and Sulfadiazine, Gm. I, Q 4 H.....	1 Case

those who were able to take sulfadiazine by mouth were given an initial dose of 4 Gm. and 1 Gm. every four hours thereafter. Those patients who were stuporous or unfit for oral administration for any reason were given an initial dose of 4 Gm. of sodium sulfadiazine intravenously and 3 Gm. thereafter intravenously every twelve hours until they were able to take the drug by mouth. Nine cases received sulfadiazine systemically according to the plan set forth above. One case received sulfadiazine systemically as well as intramuscular penicillin. Three patients were given 10,000 units of penicillin intrathecally daily along with the intramuscular administration of 25,000 units of penicillin every three hours. This series is too small to determine the efficacy of such a therapeutic program. What the ultimate answer to this problem will be is yet to be revealed. In treating ventricular wounds, by rule of thumb, we have now adopted the policy of leaving 10,000 units of penicillin in the open ventricle and of giving sulfadiazine either by vein or mouth in sufficient quantities to maintain a satisfactory blood level. For systemic use sulfadiazine is preferred to penicillin in as much as the latter does not pass the blood brain barrier. We reserve the intrathecal administration of penicillin for wounds with an excessive

amount of contamination, for those cases with a long time lag, and finally for those with obvious signs of intracranial infection.

**Complications.** There were three postoperative complications. (Table x.) One case was complicated by the laking of cerebrospinal fluid beneath the scalp about the wound, one patient had a postoperative intracerebral clot, and another developed bilateral bronchopneumonia with small multiple pulmonary abscesses. The later complication led to a fatal termination and the case will be discussed further under mortalities.

TABLE X	
POSTOPERATIVE COMPLICATIONS AND THEIR OUTCOME	
Complications	Outcome
1. Laking of Cerebrospinal Fluid Beneath Scalp.....	Cured
2. Recurrent Hematoma in Tract	Removed at General Hospital in Rear Echelon
3. Bilateral Bronchophenumonia, with Multiple Small Pulmonary Abscesses.	Death 14th Post-operative Day

The case which developed a laking of cerebrospinal fluid beneath the scalp about the wound was that of a soldier with a large penetrating wound of the left lateral ventricle in the frontotemporal region. The wound of the ventricle was sufficiently large to permit profuse drainage of cerebrospinal fluid and thereby furnish a lead as to the depth of the tract prior to operation. During the débridement three moderately large bone fragments were removed from the ventricle. The dural defect was closed with a temporal fascia transplant and closure of the scalp was effected in two layers by interrupted sutures of fine silk. On the fourth postoperative day a collection of fluid was noted beneath the scalp. Thirty cc. of faintly blood-tinged fluid were aspirated and the cavity thereby collapsed. The scalp was taped firmly against the bone by means of  $1\frac{1}{2}$  inch strips of gauze moistened with collodion which encircled the head completely. A skin tight plaster cap was then applied and left *in situ* for twelve days. Upon removal of the cast

the scalp was found to be firmly attached to the skull and the scalp overlying the bony defect was concave. At the time of evacuation on the eighteenth postoperative day the wound was completely healed.

In spite of an average time lag of sixteen hours for this series of cases, there was no evidence of wound infection in any at the time of evacuation to the General hospitals. These data are of questionable value because of the short postoperative period of observation, average holding period of this group of patients being seven and one-half days. Unfortunately, our evacuation policy varies considerably from time to time depending upon the tactical situation and the availability of beds in the Army area. During the final days of Anzio it was necessary to evacuate two of these patients by air on the second and third postoperative days, respectively; however, during other periods of less stress it was possible to observe these patients for a sufficient length of time to be sure of their wound status. We hope to obtain follow-up information in the near future on all of these wounds in order to know the end result of each.

There was one postoperative hematoma in this series which was successfully removed at a General hospital. The case was that of a soldier who had a penetrating wound of the right frontal region, the missile passing through the falx, left lateral ventricle, and came to rest in the left parietotemporal region. At the initial débridement the tract was followed down to the falx where a large intracerebral hematoma was found and removed. The 1.5 by 1 cm. metallic foreign body was situated in the left parietotemporal region and therefore was not accessible through the wound of entrance. Four days later after having been evacuated to a General hospital, the patient developed a left hemiparesis, became stuporous, and his temperature rose to  $104^{\circ}\text{F}$ . At operation a moderate size intracerebral hematoma was found in the tract on the left side as well as a large hematoma and numerous

smaller ones in the left lateral ventricle. These hematomas, the metallic foreign body, and two small bone fragments were removed; however, the brain remained tight. Therefore, the right frontal wound was reopened and at the bottom of the tract in the right brain near the falx a hematoma 1½ inches in diameter was found and removed. Following this the brain relaxed. The patient developed a "hypothalamic syndrome" for twenty-four hours and thereafter his convalescence was uneventful save for an attack of hepatitis with jaundice.

*Comment.* This case illustrates the dire necessity for absolute hemostasis in intracranial surgery. The left hemiparesis and the failure of the brain to relax following the removal of the left hematomas indicate that the large hematoma on the right side at the site of the initial operation was the chief etiological agent for the patient's difficulties.

TABLE XI  
OPERATIVE MORTALITY FOR PENETRATING WOUNDS OF VENTRICLE COMPARED TO OPERATIVE MORTALITY FOR PENETRATING WOUNDS OF BRAIN

Type of Wound	Number Cases	Deaths	Mortality Rate
Wound of Ventricles (Group II)	13	2	15.4%
Penetrating Wound of Brain Without Implication of Ventricles.....	75	5	6.7%
Total.....	88	7	7.9%

*Postoperative Deaths.* There were two deaths among the thirteen operative cases with wounds of the cerebral ventricles, giving an operative mortality of 15.4 per cent. Because of the short holding period in the evacuation hospital and because of the small number of cases involved these figures lose much of their significance. Table XI is a study comparing the operative mortality rates of penetrating wounds of the brain with and without ventricular involvement. (Table XI.) The seventy-five

penetrating wounds of the brain used for comparison were done in the same hospital under the same conditions, and over the same period of time as the thirteen ventricular wounds. It may be said, therefore, that the two series are parallel in every respect save the type of disorder. It is evident that the postoperative mortality for ventricular wounds is almost two and one-half times that for the ordinary penetrating wound of the brain without implication of the ventricular system.

The circumstances of the two deaths in group two can best be told by a brief résumé of their case histories.

CASE I. This patient sustained an irregular, penetrating wound, 6 by 5 cm., just to the left of the mid-line in the parietal region with massive destruction of scalp and cerebral herniation, radiating fracture lines from bony defect to left frontal and occipital regions as well as across mid-line to right parietal region. Coma was present, the blood pressure was 140/90, pulse 90 to 160, respirations 12 to 28 and Cheyne-Stokes in type. The pupils were equal and reacted to light; there was triplegia, bilateral hyperreflexia lower extremities and right upper extremity, bilateral ankle clonus and extensor response to plantar stroke on both sides. At operation the tract was found to extend downward and forward parasagittally, and there was a large amount of pulped brain. Two bone fragments, 2.5 by 2 by 0.3 cm. and 1.5 by 1 by 0.3 cm, were removed from the corpus callosum, and a 2 by 1.5 by 0.5 cm. bone fragment was removed from the left lateral ventricle which was free of clots. Ten thousand units of penicillin were placed in the left lateral ventricle; closure of the dura was carried out with fascia lata transplant, scalp closure with plastic flap and intermediate skin graft. There was a febrile reaction of 103° to 105°F. throughout the postoperative course, respirations 28 to 50, pulse 116 to 164; the patient was comatose five days and stuporous thereafter; he received penicillin intrathecally daily and intramuscularly every three hours; C. S. F. white cell count 91 on the first postoperative day, 14 on the third, 12 on the fourth and 5 on the sixth postoperative day. He developed bilateral signs of pulmonary consolidation one week after



injury; death occurred on the fourteenth post-operative day. At autopsy both lungs showed extensive spotty consolidation with multiple small areas of necrosis. The brain did not show any evidence of local or diffuse inflammation. There were no intracranial or intracerebral hematomas. The immediate cause of death was bilateral bronchopneumonia with multiple lung abscesses.

*Comment.* This case illustrates the great hazard of pulmonary complications in comatose and paralyzed patients. The immediate and continuous febrile course was highly suggestive of a hypothalamic syndrome. Unfortunately, the pathological report did not include a gross description of the sectioned brain. The normal cerebrospinal fluid cell counts would seem to indicate that the febrile reaction was not due to an acute spreading intracranial infection.

CASE 11. The patient received a gunshot wound, right frontal to left occipital region; coma was present; pulse was 92 to 142, respirations 40 to 50 and stertorous. The pupils were small, equal and reacted to light. All extremities were spastic and in extension; there were bilateral hyperreflexia, ankle clonus, bilateral positive Babinski and Hoffman. At operation the brain was not tight. There was massive brain destruction. The tract was found to transverse the right lateral ventricle; bone fragments and small clots were removed from the ventricle. Closure of dura was performed with fascia lata transplant. A 3.5 cm. opening was made in the left occipital region and a bullet was found at a depth of 4 cm. The tract in the left hemisphere was débrided and found to transverse the occipital pole and left lateral ventricle. There were minimal blood clots in the left lateral ventricle and a large amount of pulped brain surrounded the missile tract on the left side. The postoperative course was rapidly downhill and death occurred thirty-seven hours after operation. Autopsy revealed a wide zone of cerebral softening about the tract extending from the right frontal to the left occipital lobe traversing both lateral

ventricles. There was no hematoma in the subdural space or ventricles.

*Comment.* This patient died of massive brain damage without increased intracranial tension. He presented a hopeless picture from the beginning which coincided with the cases described in group one, namely, perforating ventricular wound associated with bilateral brain damage, coma, wide pulse pressure, rapid pulse, rapid irregular respirations and short survival period. The advisability of operative interference in this case with signs of impending death is open to question. It has been our policy not to make a separate wound in order to remove a metallic foreign body which because of its remoteness is not accessible through the wound of entrance. This is one of the few exceptions that we have made to this rule. The missile was sought in this case because a ventricular wound on the left side and the possibility of an intraventricular hematoma was suspected.

#### SUMMARY

1. Sixteen cases with wounds of the ventricles are reported and are presented in two groups.
2. Group one is composed of three patients who were admitted to the hospital with signs of impending death and had short survival periods.
3. Group two is composed of thirteen operative cases with two fatalities.
4. The operative mortality for penetrating wounds of the ventricles is two and one-half times that for penetrating wounds of the brain without ventricular involvement.
5. Intracranial infection was not a factor in any of the deaths.
6. Bilateral and bipolar ventricular wounds usually lead to an early fatal termination.

# EXPERIENCES IN TREATMENT OF TRAUMATIC CAVITATION IN THE UPPER TIBIA\*

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THE high velocity weapons of modern warfare have produced a greater number of destructive wounds, both of the soft tissue and of the bone structure, than ordinarily are seen in the course of a traumatic surgery practice, and the factor of direct violence in the causation of the fractures encountered produces many unusual and unexpected results. The cases presented in this paper are a group which we have dubbed the "Cavity Club" at this activity. The term arises from the through-and-through cavitation in bone and the overlying soft tissue defect.

The treatment of any fracture during an active engagement is modified somewhat by the military demands of the situation and by the facilities immediately available at the time and place of the injury. The initial treatment of compound fractures of the extremities has been standardized to some extent both by experience and by directive. The immediate treatment is directed toward adequate care of the patient as a whole; control of shock, hemostasis, early careful débridement, adequate immobilization of the fracture, and augmented by systemic use of the sulfonamides and penicillin.

Definitive treatment often is not possible early, but the advancement in transportation of casualties, and the present emphasis on bringing the medical officer to the casualty, have resulted in elimination of the time lag between first aid and definitive treatment.

The experience of Orr<sup>15</sup> in World War I and the continuation and advancement of his work by Truetta<sup>16</sup> in the Spanish Civil War have had their effect on the treatment of compound fractures. The ad-

vent of the sulfonamides and penicillin, despite the early enthusiasm for their use, has modified the treatment of compound fractures only to the extent of possibly preventing overwhelming sepsis in a certain number of cases, and facilitating earlier operation for the repair of bony defects.

The management of the cases in this presentation provides a two-fold problem: the management of the fracture and the treatment of the soft tissue damage. The primary aim in the clinical course of these cases has been the treatment of the fracture in order to provide the maximal functional end result. Moore<sup>2</sup> insists that conversion of the compound fracture into a simple fracture is a prerequisite for successful repair of bone defects. In order to adhere to this dictum, the first attentions were directed to control of the infection at the site of the fracture. The extensive soft tissue damage caused by the size and velocity of the fragments, and the loss of substance exhibited by all these cases made more difficult the preparation of the patient for future reconstructive surgery.

The experiences of Key<sup>5</sup> in the treatment of chronic osteomyelitis led him to conclude that systemic and local use of the sulfonamides in combination with excision and saucerization permitted earlier surgical procedures and greater safety in primary closure. These conclusions were corroborated by Foster<sup>6</sup> in his treatment of forty-eight compound fractures. Further, Foster compared his treatment with the sulfonamides with his previous use of the Carrel-Dakin method and found it to be distinctly more effectual.

\* The opinions expressed in this paper are those of the authors and not of the Navy Department. This paper has been released for publication by the Navy Department.



FIG. 1. Case 1. A, admission x-ray; B, present x-ray.



FIG. 1. Case 1. C, Present cavity wound dry.

The use of penicillin further abetted the treatment of compound fractures. Lockwood<sup>7</sup> found that penicillin was effective in acute hematogenous osteomyelitis as well as in chronically draining sinuses. In sinus producing lesions caused by organisms sensitive to penicillin, he reports healing without sequestration in two to three weeks.

A further consideration in the treatment of war casualties is dermoplastic repair of the overlying soft tissue defect. Pick,<sup>11</sup> in his scholarly article, advocates early grafting of such defects and reports excellent results. He maintains that in war casualties

there must be some modification of the usual civilian treatment of such defects, his most important reasons being the greater area involved, and the greater destruction usually encountered in such wounds. His technic produced good results in fifty unselected cases, with reductions in hospitalization ranging from eight to ten months. Kelly<sup>12</sup> also reports early grafting in combination with saucerization in one hundred cases, with fair to excellent results in 72 per cent. He states that fractures with a deep cavity and overhanging edges are not suitable for early grafting. The cases presented here are of this type, with through-and-through cavities in the bone and a deep soft tissue defect.

#### CASE REPORTS

CASE 1 R. S., a private was wounded by fragments of a hand grenade July 20, 1943. His initial treatment consisted of débridement and traction by pins through the os calcis and femur. The pins were removed September 13, 1943. He was given sulfathiazole gr. 15 every four hours for five days. Examination on entry to this hospital revealed a well nourished white male in no acute distress. The pin holes drained purulent material. There was complete loss of function of the left common peroneal nerve. There was 30 degrees motion of the knee joint. Culture revealed *Staphylococcus albus* and *aureus*. Penicillin 20,000 units every four hours was initiated. X-rays revealed a comminuted fracture of the left tibia with sequestrae. Operative treatment consisted of a sequestrectomy and curettage of the tibia on January 26,



FIG. 2. Case 11. A, admission x-ray; B, present x-ray.

1944, excision of the sinus of the lateral aspect of the thigh with curettage of the pin site June 9, 1944, and excision of the sinus and sequestrectomy of medial thigh October, 10, 1945. There was clinical union May 16, 1944, and strong x-ray union by November of that year. The wound of the anterior aspect of the tibial flare was epithelialized by September of 1945. The predominant organism on culture for the last six months of drainage was *Bacillus proteus*. Local treatment of the cavity consisted of courses of Dakin's solution, azochloramid, sulfathiazole, red cells and penicillin.

**CASE. 11.** E. S., a private was wounded in September, 1944, by mortar fragments through the left tibia. His initial treatment consisted of débridement and cast. Roger Anderson pin fixation was applied four days later. The pins were removed March 1, 1945. He was given intensive sulfathiazole and penicillin therapy from the date of injury. Examination on entrance to this hospital revealed a well developed, well nourished white male, not ambulatory. There was a defect in the upper third of the tibia and overlying tissue measuring 3 by 6 cm., which was packed with vaseline gauze. A sequestrectomy was performed December 11, 1944, and the pins were removed because of purulent drainage January 1, 1945. A foreign body (shrapnel) was removed from the posterior aspect of the leg on June 25, 1945. There was clinical union by March 1, 1945. The patient was ambulatory from this date in a walking caliper. The defect on the anterior aspect



FIG. 2. Case 11. C, present cavity; slight serous discharge still present.

of the tibia has continued to epithelialize at a slow rate. It is not completely covered at the present time. Predominant organism on culture was *Bacillus proteus*. Local treatment of

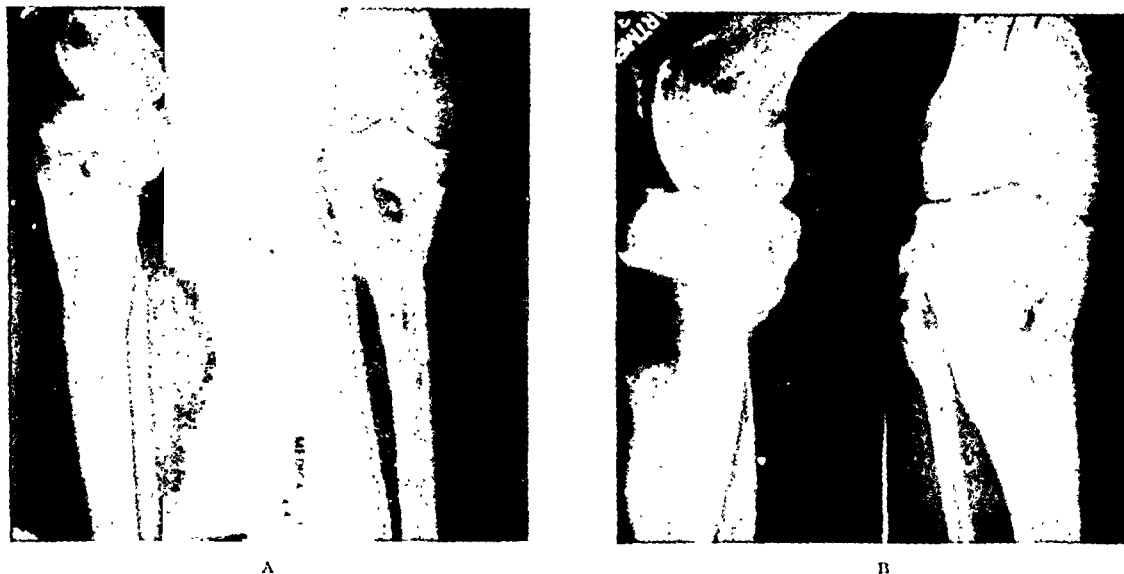


FIG. 3. Case IV. A, admission x-ray; B, present x-ray.



FIG. 3. Case IV. C, present cavity wound dry.

the cavity consisted of packing with vaseline gauze, local sulfathiazole, local penicillin and tyrothricin.

CASE. III C. R., a private was wounded by multiple shrapnel fragments on January 10, 1945. His initial treatment consisted of anti-

shock therapy, débridement with vaseline gauze pack, and immobilization in plaster. Examination on entrance to this hospital revealed a superficial wound of the lateral aspect of the left mid-thigh and lower leg, and traumatic amputation of his right great toe. The wound of the thigh was one inch in diameter, and that of the upper end of the tibia 2 by 4 inches. Treatment consisted of sequestrectomy April 30, 1945, vaseline gauze packing, and immobilization in plaster. The wound at present has epithelialized 70 per cent of its surface. Knee motion is 10 degrees. Therapy consisted of systemic use of penicillin, local penicillin and tyrothricin 2 per cent. The patient was ambulatory in a walking caliper June 21, 1945.

CASE IV. B. H., a private was wounded on September 10, 1943, in the right tibia by the accidental discharge of a .50 calibre machine gun. The slug penetrated the upper end of his tibia from above and followed a downward and outward course. Initial treatment consisted of débridement and hemostasis. The patient was then placed in a cast. Examination on entrance to this hospital revealed a well nourished white male with a profusely draining cavity on the anterior aspect of the right tibia, measuring 2 by 3 by 2 cm. Systemic treatment consisted of intensive sulfonamide therapy at the time of injury and during evacuation, and later intensive penicillin therapy. Operative treatment consisted of a sequestrectomy May 25, 1944, at another hospital, and first, second, and third stage pedicle graft attempts, also at another hospital. Another sequestrectomy was done



FIG. 4. Case v. A, admission x-ray; B, present x-ray.

June 15, 1944. The patient had a complete peroneal palsy on the right. There was clinical union of the fracture December 24, 1943, and x-ray union December 27, 1943. On September 1, 1945, the cavity ceased draining and the wound was epithelialized.

CASE. V. G. F., a private, was wounded by mortar shell fragments in both legs on June 16, 1944. He incurred a through-and-through injury of the right leg at the junction of the lower and middle thirds, and in the left a wound with destruction of the patella. The left anterior wound measured 3 by 2 inches, and the left posterior 2 by 1 inches. Initial treatment consisted of first aid and application of a cast. Examination on entrance to this hospital revealed a well developed, well nourished white male in no acute distress. His operative treatment consisted of a sequestrectomy of the tibia and packing with vaseline gauze. He had intensive penicillin therapy, both local and systemic, permease locally to the wound, and sulfonamides locally. The cavity over the anterior portion of the left tibia is not completely epithelialized to date. The predominant organism on culture is *Bacillus proteus*, which is responding to acetic acid.

CASE VI. G. S., a private was wounded on June 27, 1944, by a machine gun bullet through the left leg. His initial treatment consisted of

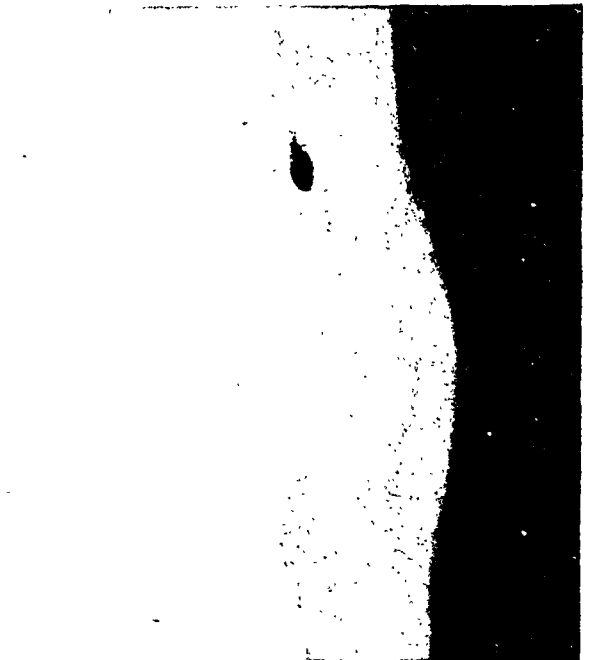


FIG. 4. Case v. C, present cavity; slight serous drainage still present.

débridement and application of a cast. From July 14 through October 7, 1944, he was in a Stader splint with pins through the tibia and through the femur. On May 27, 1945, his wound was curetted, and on September 10, 1945, the pin hole in the tibia was curetted. He had intensive sulfonamide therapy both systemically and locally. On entrance to this

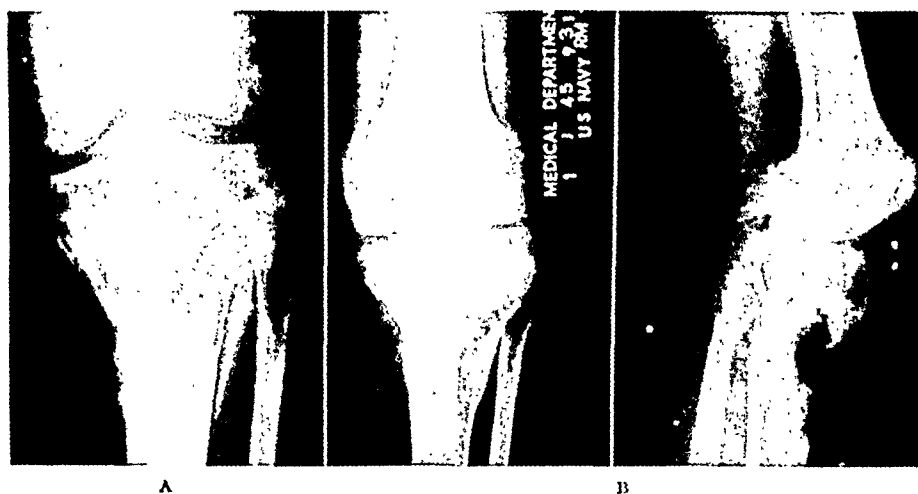


FIG. 5. Case VII. A, admission x-ray; B, present x-ray.



FIG. 5. Case VII. C, present cavity wound dry.

strating aircraft, sustaining a compound fracture of the upper right tibia. Initial treatment consisted of immobilization in a Thomas splint, débridement, and packing with vaseline gauze after installation of sulfonamide powder. He was then immobilized in plaster. Sequestrectomies were performed on May 4 and November 9, 1944, and March 29, 1945. Intramuscular injections of penicillin were administered for thirty-eight days, totalling 4,380,000 units. Drainage ceased August 27, 1945, and at present the wound is completely epithelialized. Disability consists of moderate atrophy of the involved leg, with marked limitation of knee flexion. The patient is fully ambulatory and asymptomatic.

#### TREATMENT

It has been advocated<sup>14</sup> that the ideal treatment of traumatic cavitation with osteomyelitis is early adequate sequestrectomy with early plastic repair of the loss of the overlying soft tissue defect, and later obliteration of the cavity by bone chips. All of the authors who advocate early grafting in defects of the soft tissue establish saucerization as a prerequisite, maintaining that the bone defects must have a continuous base for skin graft application. Such treatment, if successful, results in a major reduction of days of morbidity. However, in similar cases we have found this regimen of treatment impossible to follow.

The therapy of the cases presented here was coordinated with the neurosurgery,

hospital, examination revealed a large draining sinus in the anterior portion of the tibia, measuring 3 by 5 cm. in diameter, and extending down to the marrow cavity. This sinus has closed after persistent drainage, and epithelialization is progressing. At present there is no drainage from the cavity. Local treatment of the cavity consisted of penicillin, permease, sulfathiazole, tyrothricin and acetic acid. There was a complete peroneal palsy which has returned 80 per cent in function.

**CASE VII.** C. H., a Lieutenant was wounded March 27, 1944, by machine gun bullets from

plastic surgery and orthopedic surgery departments of this activity, with frequent interdepartmental consultations throughout the progress of the treatment. Table I chain of evacuation of each battle casualty, with an interval averaging 3.66 months from time of injury until the first treatment given here. Each patient had an early

TABLE I

Patient	Injury	Hospital Days	Joint Motion (present)	Nerve Involvement
R. S.....	compd. fr. left tibia and fibula	830	left knee ext. 175° flex. 140°	left peroneal complete
E. S*.....	compd. fr. left tibia and fibula	389	left knee ext. 180° flex. 93°	none
C. R.....	compd. fr. left tibia and fibula	335	left knee ext. 170° flex. 160°	left peroneal complete
B. H.....	compd. fr. right tibia and fibula	213	right knee ext. 180° flex. 80°	right peroneal complete
G. F.*.....	compd. fr. right tibia and fibula; left. tibia, patella, and fibula	755	right knee-full left knee ext. 180° flex. 145°	left peroneal complete
G. S.....	compd. fr. right tibia and fibula	473	right knee ext. 180° flex. 125°	right peroneal complete
C. H.....	compd. fr. right tibia and fibula	570	right knee ext. 170° flex. 140°	none

\* Wound not completely epithelialized.

TABLE II  
CULTURES

Patient	B. Pyocyaneus C. Welchii	Strep.	Staph. Albus	Staph. Aureus	Hemolytic Strep.	B. Proteus	G. negative baccilli
R. S.....	o	+	+	+	+	+	+
		(os calcis)		(os calcis)			
E. S.....	o	o	+	o	o	+	o
C. R.....	o	+	+	+	+	o	o
B. H.....	+	+	o	+	o	+	o
G. F.....	o	+	+	+	o	+	o
G. S.....	o	o	+	o	o	+	o
C. H.....	o	o	+	+	o	o	o

details the fractures and the nerve involvement encountered. Table II is a compilation of the reports of cultures taken at frequent intervals from the drainage sites. Tables III and IV represent the total treatment, a combination of the antibacterials and the surgery received in each case.

This activity was the final stage in the

débridement with removal of nonviable fragments of bone, and with reduction of the fracture without internal fixation. Cases V and VI had subsequent sequestrectomies with confirmation by x-ray of the removal of all possible sequestrae. Due to the persistency of their drainage, Cases I, IV, V, and VI had subsequent curettages.



TABLE III  
OPERATIONS

Patient	Débridements	Sequestrectomies	Pins	Cast	Plastic
R. S.....	++	++ excision lat. & med. sinuses thigh	+	+	o
E. S.....	++	+ removal shrapnel	+	+	o
C. R.....	+	+	o	+	o
B. H.....	+	++	o	+	+++ (failures)*
G. F.....	+	+	+	+	o
G. S.....	+	+	+	+	o
C. H.....	+	++	o	+	o

\* At another activity.

TABLE IV  
SYSTEMIC TREATMENT WITH ANTI-BACTERIALS

Patient	Sulfonamides		Penicillin		Tyro- thricin	Red Cells	Permease	Acetic Acid
	Local	Systemic	Local	Systemic				
R. S.....	+	+	+	+	o	+	o	+
E. S.....	+	+	+	+	+	o	+	+
C. R.....	+	+	+	+	+	o	o	o
B. H.....	+	+	+	+	+	+	+	+
G. F.....	+	+	+	+	+	o	+	+
G. S.....	+	+	+	+	+	o	o	+
C. H.....	+	+	+	+	+	o	o	o
			5 days	3,400,000 U	37 days		3 weeks	
				6,230,000 U	20 days		3 weeks	
				850,000 U	15 days			
				9,600,000 U	15 days			
			25 days		15 days			
			7 days	4,380,000 U	o			

TABLE V

Patient	Bed Days (not Amb.)	Clinical Union	Days Drainage	Hospital Days
R. S.....	194	296	815	830
E. S.....	161	120	*389	389
C. R.....	163	150	330	330
B. H.....	516	100	715	755
G. F.....	230	115	*485	485
G. S.....	126	126	473	473
C. H.....	350	360	450	570
Average.....	248 $\frac{3}{4}$	181	522 $\frac{3}{4}$	547 $\frac{3}{4}$

\* Wound not completely epithelialized.

The cases of this series had cavitation of the tibial flare in close proximity to the knee joint, near the tibial tubercle, and the fractures involved the articular surface of the tibia. Classic saucerization, demanding radical excision of bone and the formation of a shallow depression with gradually shelving sides and a smooth, continuous base, was deemed impossible. Excision of bone in this area would have deranged the joint structure, jeopardizing the future joint motion and disturbing further the already architecturally weakened tibia. Moreover, the smooth, continuous base was impossible to achieve with a penetrating wound. Sequestrectomy, with elimination of bone spurs, overhanging edges, and infected bone areas proximally, with saucerization distally, had to substitute for the more radical procedure.

Immobilization of the fracture was accomplished in all cases by the application of plaster. Four of the patients also had some type of pin traction, three of which were Stader splints, and the other of the Roger Anderson type. All had purulent drainage around their pin sites, positive on culture for pyogenic organisms, which necessitated early removal of the pins. Case I developed a clinical osteomyelitis of the os calcis at the pin site, confirmed by culture, x-ray and pathological examination of curettages. Case VI has drainage at one pin site at present after two curettages.

The culture reports dictated the use of the sulfonamides and penicillin systemically, since each showed organisms for which those drugs are specific. Sulfadiazene was administered in adequate dosage to each of the cases from the time of injury until the first stage in the evacuation chain, an average of nineteen days. Further administration was not recorded until admission to this hospital. Each had sulfanilamide powder instilled at the time of débridement and at each later surgical procedure.

Penicillin was administered systemically in every case at each activity where these patients were admitted. The totals received

at other activities are not recorded. The totals administered in this hospital are compiled in Table IV. Case VI developed an allergic response to penicillin in the form of giant urticaria after 100,000 U. had been administered. It is considered that these dosages represent more than adequate amounts of the drug for the control of the usual infections encountered in compound fractures. The use of penicillin in these cases probably aided in the prevention of sepsis and further local spread of the infectious process. In Cases I, IV and VI amputations had been seriously considered at various times. We believe that the localization of the infection can be ascribed to the action of penicillin, making amputation unnecessary. Maggot therapy was considered but the maggots were not available.

On entrance to this hospital each patient had a plastic surgery consultation, and the opinion in each case was that any repair should be delayed until drainage had ceased and the area was covered with granulation tissue suitable to grafting. It was considered that plastic repair would be inadvisable and fruitless in the face of underlying bone infection. Furthermore, the impossibility of saucerization for the complete removal of all infected bone to prepare a satisfactory bed for skin grafts excluded dermoplastic repair. As an alternative, local treatment of the cavitation was advised in order to encourage epithelialization.

On the suggestion of this department, local treatment of the cavitation was carried out with the sulfonamides, penicillin, soaks and powder, 2 per cent tyrothricin for the number of days shown in Table IV, suspensions of red blood cells in the cases indicated, permease, and in the wounds positive for *Bacillus proteus*, 1 per cent acetic acid soaks.

Assessment of the efficacy of local treatment was based primarily on clinical observations of the amount of drainage, the appearance of the wound and granulation tissue, and the progress of epithelialization of the cavity. Another criterion was succes-

sive culture reports. The purpose of the local use of the antibacterials was to attain and maintain a healthy, relatively clean granulating area, diminution of the amount and alteration of the character of the drainage and an increased rate of epithelialization.

The effect of local treatment with the sulfonamides was found to be negligible. Neither was the purulent character altered nor the amount of drainage diminished with their use.

Each wound, with the exception of Case VII, was positive on culture for *Bacillus proteus*. Acetic acid soaks, 1 per cent, were found to be efficacious in rapid elimination of these organisms. Permease was used in three cases with unsatisfactory results. The most effective agents were penicillin and tyrothricin, and of these our experiences have led us to believe that penicillin was most practical and most satisfactory.

In addition to these agents, careful aseptic technic was employed in the dressings of these wounds. The changes of dressings were effected at intervals demanded by the condition and progress of the wound. It is emphasized that these local measures were instituted for their beneficial effects on the soft tissue wound, and were not directed toward the underlying osteomyelitis.

The cooperation of the neurosurgery department was sought in the determination of the treatment of the nerve involvement. All of the cases involving fracture of the tibia and fibula, with two exceptions, had involvement of the common peroneal nerve, with a subsequent foot drop. It was the opinion of the neurosurgical department that neurorrhaphy without acute flexion of the knee was impossible. Moreover, nerve suture was not considered feasible in the presence of infection.

Table v compiles the intervals between union and weight bearing, days of drainage and hospital days. The long interval between clinical union and full weight bearing was necessitated by a type of fracture causing architectural weakness of the tibia. Weight bearing, partial to complete, was

advised as early as the x-rays and clinical examination indicated. All were started on weight bearing either in walking casts or calipers. The psychological benefit attained by early weight bearing can hardly be measured accurately, but was quite appreciable to those of us in close contact with the patients. At present all patients are weight bearing without braces. They participate in all patient activities at this command: swimming, bowling, dancing and extramural activities.

After cessation of drainage and epithelialization in four of the cases presented, consideration was given to further orthopedic procedures of a reconstructive nature. Review of the clinical status of these patients led to the decision against further surgery, after consideration of the several factors involved. Their uneventful progress lends strong argument to the decision that obliteration of the cavities by surgical measures is not necessary. In our opinion, the placement of bone chips or grafts in an area of chronic infection offers little hope of success. Furthermore, the trauma occasioned by any surgical procedure is more than likely to light up latent infection, even after cessation of drainage and closure of sinuses with epithelialization of the cavity. The results evidenced by x-ray of the filling in of the bone cavity and the asymptomatic use of the involved legs by the patients helped further to decide us against reconstructive surgery. In addition, the fact that the organisms involved were of a rather virulent type adds greater weight to the arguments. Late skin plastic procedures were not considered advisable due to the fact that the underlying defect of bone would prevent correct plastic repair, and for the reason that these procedures might well reactivate the infection.

#### SUMMARY

Seven cases of compound fractures of the tibia and fibula are presented. All of the fractures involved the upper flare of the tibia, and all developed osteomyelitis with persistent drainage from a through-

and-through cavity of the tibia. The treatments were long, persistent and varied, with each type given a thorough trial. Four of the cases are completely epithelialized. All are ambulatory and asymptomatic with some limitation of motion at the knee. The treatment here outlined is conservative, with sequestrectomy, immobilization, systemic antibacterials and early weight bearing.

### CONCLUSIONS

1. The fractures herein considered present a peculiar and difficult problem.
2. Penicillin, systemic and local, is a major aid in the surgical treatment of compound fractures with osteomyelitis.
3. Surgical attack on infected cavities of the upper tibial flare is limited by anatomical considerations.
4. The presence of continued infection prohibits definitive reconstructive surgery in these cavities.

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# PRACTICAL MANEUVERS IN ABDOMINAL SURGERY\*

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**I**N the course of many years' experience in surgery of the abdomen there are certain procedures that we have learned to recognize as being extremely helpful. One often observes a surgeon operate with total disregard of the known basic anatomical points. Much less does he consider the normal physiology of the part involved or the response of the tissues to trauma and other pathological processes. It is our purpose to emphasize practical methods in the management of the more common intra-abdominal operations.

In order to give the patient the best possible treatment there must be complete co-operation between the surgeon and the anesthetist. It is futile and shocking to begin a major surgical operation before the patient is completely anesthetized. Furthermore, at any stage of the procedure if the abdominal wall should become rigid, or, if in mobilizing any abdominal viscera, he should retch, it is obligatory to halt until anesthesia is deepened. The struggle to expose an organ or the vain attempt to close the peritoneum while the patient is making violent diaphragmatic thrusts is prohibited. There is no doubt that the conduct of a surgical operation in the well anesthetized patient is esthetically satisfying and physiologically sound. It lessens trauma as well as bleeding; consequently shock, postoperative ileus and pulmonary complications are diminished.

We have learned to value the many advantages afforded by the transverse incision and its variations in surgery of the upper abdomen. It is particularly useful in approaching the gallbladder, stomach, colon and spleen. These patients enjoy an amazing freedom from postoperative pain. They are able to breathe deeply and cough easier, hence have fewer pulmonary com-

plications, as compared to the patients who have had the more conventional linear incisions. This is, perhaps, due to less interference with the abdominal nerves, or, to transection of the rectus muscle which eliminates spasm. It seems almost trite to add that any incision should be amply long to facilitate the surgical procedure at hand. The use of buttonhole type of incisions should be discouraged.

In the surgery of the pelvis the senior author has emphasized the value of the Trendelenburg position in beginning anesthesia. It is more successful than beginning in the dorsal position and then changing because it gives the diaphragm time enough to pull the intestines out of the pelvis. If a change of position is made while the patient is becoming anesthetized, it may frighten her and start straining or coughing, either of which mars the success of the method. After making a small opening in the peritoneum, the abdominal wall is lifted by two fingers and the in-rushing air will induce intestinal coils, which have not moved out of the pelvis, to slide upwards. Thus one gets maximum exposure with minimum trauma. The need for gauze packing is eliminated.

The incision is made by clean, bold strokes of a sharp scalpel and is then sponged sparingly. Points of active bleeding are accurately grasped with fine forceps and then ligated with fine sutures. The fitful sponging or brushing of the already traumatized fatty tissue is to be deplored because it adds to the incidence of post-operative wound complications. These complications may be collections of serum, hematomas or infections with subcutaneous abscess formation.

In entering the abdomen through a transverse incision it is easier to open the

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peritoneum at the linea alba. Then, by using the fingers to lift the abdominal wall, the rectus muscle, its sheath and the peritoneum are cut through at once. This approach allows better control of the bleeding vessels in the muscle, lessens the hazard of injury to underlying viscera and is appreciably quicker than cutting each one of the structures separately. Incisions for exposure of the pelvis are usually made in the mid-line but the abdominal cavity is entered on either side of the linea alba by incising the rectus sheath and then separating its fibers. This incision is conducive to a stronger wound which is less apt to disrupt or later to herniate.

When the peritoneum is opened one frequently wishes to explore viscera distant from the site of incision. To accomplish this neatly, the abdominal wall is elevated by the examining hand. Making certain that nothing comes between the fingers and the slippery peritoneal surface, the hand slides along until the desired point is reached. In this manner the liver and gallbladder can be accurately palpated from the pelvis. It is equally easy to appraise the pelvic organs through an upper abdominal incision.

In all manipulations it is of paramount importance to be extremely gentle. With this in mind, all superfluous gauze packs or sponges are kept out of the abdominal cavity. Gauze traumatizes the delicate cells of the peritoneum, interrupts the nerves of conductivity, temporarily interferes with peristaltic action and thus increases the tendency to intestinal ileus and postoperative shock. One gauze square, saturated with physiological saline solution, is practically all that is ever needed to keep the intestines away from the operative field of the pelvis when the patient is in the Trendelenburg position. If the movable cyst or fibromyoma can be delivered through the incision, it is necessary to use but part of the gauze square. Using the broad, curved Deaver retractor, a part of a gauze square is also sufficient for exposure of the gallbladder or common duct if

there is proper anesthesia and the liver is mobilized correctly. If the appendix is removed through the usual muscle splitting incision, the insertion of any gauze into the abdomen is superfluous.

When examining the duodenum or stomach for peptic ulcer one looks for fine, red, stipple marks. These may be found on a background of paler and somewhat puckered muscle. Until this area is recognized the tissues should not be pinched with the fingers or clamped with an instrument. Trauma will quickly produce similar subserosal, petechial hemorrhages which appear as red stippling.

We use the open method of gastric resection either with or without the automatic clamp sewing machine. In appraising the pathological condition present and the resectability of the stomach it is necessary to enter the lesser peritoneal cavity. This is easily done by making an opening in an avascular area on the lesser curvature through the gastrohepatic ligament or on the greater curvature through the anterior reflection of the gastrocolic ligament. Some of the most difficult ulcers to resect involve the posterior duodenal wall where they may have partially perforated and are densely adherent to the pancreas. Here it becomes imperative to identify, yet not injure the common duct. A surprising amount of the duodenum can be mobilized by incising the lateral reflection of the peritoneum. Likewise, in mobilizing the lower esophagus for total gastrectomy an inch or more can be gained by incising its peritoneal reflection. If the resection is done for malignancy or if one wishes to do an anterior anastomosis, the omentum is removed by sharp dissection at its juncture with the colon in the avascular zone first described by Alessandri. As proposed by Lahey, the stomach can then be turned upwards and used for traction while the first row of sutures is placed. This procedure is particularly helpful in total gastrectomy.

In exposing the cardiac end of the stomach and the esophagus, excellent ex-

posure may be obtained by severing the left triangular ligament of the liver from the diaphragm and raising the left lobe of the liver out of the left hypochondrium. We usually use the full width of the stomach for the anastomosis. The angles are closed with particular care so that serosa meets serosa. This exactitude together with an accurate hemostatic stitch on the first row of sutures in the anastomosis is absolutely essential to the success of the procedure. In the usual resection we have found that a short posterior, no-loop anastomosis is very satisfactory. At every operation on the stomach, the gallbladder and common duct should be inspected for stones or other pathologic change. Likewise, in all surgery involving the gallbladder, the stomach and duodenum should be examined for ulcer. Simultaneous gallbladder disease with stones and peptic ulcer is not uncommon.

*Gallbladder and Common Duct.* Before undertaking any definitive operative procedure on the gallbladder it is imperative to inspect the common bile duct. It is opened if there is a history of frequent attacks with intermittent jaundice and fever, if it is dilated and if the bile aspirated with a fine needle is not perfectly clear. However, the choledochus should not be opened unless some definite indication exists. After it has been determined that the common and the hepatic ducts are patent and that the ampulla is unobstructed, the gallbladder may be resected. If there is a stricture of the ampulla which cannot be gently dilated, or a tumor, cholecystectomy should not be performed unless the gallbladder is contracted and functionless. Unless the difficult operation of resection of such a lesion in or about the ampulla is undertaken, the usual alternative is to establish another bile passageway by performing a cholecysto-jejunostomy or the less desirable cholecysto-gastrostomy. When the gallbladder is distended, it can be removed much easier if first aspirated through the fundus. If operative intervention is undertaken for a greatly distended,

inflamed or gangrenous gallbladder, it is wiser to shell out the thickened mucosa as much as possible and to destroy any remaining mucosa with phenol. This is quicker and fraught with much less danger in these very ill patients than is the conventional cholecystectomy. If one enters the right layer, this "compromise" cholecystectomy can be rapidly executed. Although we believe that the removal of the gallbladder is the procedure of choice in dealing with cholelithiasis, we are satisfied with cholecystostomy if the patient's condition makes the more extensive operation hazardous or, if it is suspected that the gallbladder may be needed for short-circuiting the bile stream later. Furthermore, when the gallbladder is filled with stones and the infundibulum greatly enlarged and adherent, its removal is simplified by first opening the fundus and removing the stones. Thus the infundibulum is not only more easily visualized but a finger can be inserted into it which may be of great help in dissection. Although there may be spillage of bile, there is no danger of infection. Wilkie has shown that the greater proportion of the cultures taken from the contents of such gallbladders is sterile.

We perform cholecystectomy in the retrograde manner. The cystic duct and its junction with the common duct is found by blunt dissection. It is clamped with a curved hemostat and then ligated with a double strand of No. 1 chromic gut on a needle. The ligature is cut long enough to extend well up into the incision so that it may serve as a guide to this critical point if leakage of bile should occur later. The duct is then severed between the clamp and the suture. The cystic artery is ligated in the same manner but the suture is cut short. Using the clamp for traction the gallbladder is then dissected away from the liver sulcus. As the dissection is carried upwards the sulcus is closed by interrupted chromic sutures. Considerable venous oozing can be eliminated by incising the peritoneal covering of the gallbladder at some distance away from its reflection onto the

liver. This leaves a broad flap from which the sutures will not tear out and the sulcus can be completely closed. A soft rubber tube is always inserted into Morrison's pouch and is brought out of the incision at or near the outer angle.

Occasionally, one has to expose a common duct which has been previously operated upon. By haphazard dissection it may be next to impossible to find it. Faced with this situation it is always helpful to locate the liver margin and then work downwards, keeping close to its surface.

Many common and hepatic ducts have been irreparably damaged by either tenting them in ligating the cystic duct or by blindly clamping the bleeding cystic artery. If these structures are identified and accurately ligated, such errors are obviated. If the cystic artery is accidentally severed or if its ligature should slip off, the bleeding, which may be quite frightening, can be absolutely controlled by inserting the forefinger into the foramen of Winslow and compressing the hepatic artery with the thumb. It is noteworthy that uncontrollable hemorrhage from a ruptured spleen or from the splenic pedicle can likewise be stemmed by compression of the lienal artery as it courses along the upper border of the pancreas.

When opening the abdomen it is frequently desirable to know approximately which portion of the small intestine is presenting and which end is nearer the cecum. Many years ago Monks called attention to this problem and its solution. His excellent work is not widely known. However, his method of intestinal localization is so valuable that its main features should be emphasized again. The mesentery arises from the posterior abdominal wall along a six inch line. It begins at the level of the second lumbar vertebra on the left side of the spinal column about where the duodenum ends. It then continues downwards and to the right to end indefinitely at a point opposite the right sacro-iliac joint. He showed that two lines running obliquely across the abdomen, one at either end and

perpendicular to a line representing the mesenteric root, would trisect the abdomen into three regions. The upper region would contain the upper third of the intestine; the middle, the middle third; and the lower region, the lower third. It is thus evident that an incision above the first line will expose loops from the upper intestine, in the middle region loops from the middle third, and in the lower region loops from the lower third of the intestine. Monks further pointed out that the jejunum is larger, thicker, more vascular and of a brighter red than the lower intestine. *Valvulae conniventes* can be felt and seen as whitish rings about the intestine within fourteen and fifteen feet of the end of the duodenum. If one lifts the intestine with its mesentery against a light, the mesenteric vessels can readily be inspected. The branches of the mesenteric artery unite by loops. From these loops straight vessels, called the *vasa recta*, run into the intestinal wall. Supplying the upper intestine there are only single or primary loops of the artery and long, regularly placed *vasa recta*. As one goes down the intestine secondary loops appear and the *vasa recta* are shorter. The secondary loops become conspicuous at about the fourth foot. As one proceeds downward, the arterial loops become more numerous and smaller, reaching close to the intestinal wall. Tertiary loops may appear near the end of the ileum and the *vasa recta* are usually less than 1 cm. long. The thinnest part of the mesentery is that in relation to the upper intestine where it is transparent and the vessels can be readily seen. Due to deposits of fat it becomes thicker and opaque as one follows the intestine downward.

The direction of the intestine can be determined by having an assistant hold up a loop between the two hands while the surgeon follows down the mesentery with two fingers. If the mesentery contains no twists and he enters the left abdominal fossa, he must be on the left side of the intestine; and if he enters the right fossa, he must be on the right side of the intestine.



When these conditions are met, the lower end of the intestine is nearer the ileocecal valve. In other words, if the mesentery is not twisted and the loop of the intestine is parallel with the mesenteric root, the upper end is the proximal and the lower the distal end of the loop. With a little practice this maneuver can be carried out in much less time than it takes to describe it. It is useful in resection of the small intestine. It is particularly helpful in doing the occasional enterostomy for small intestinal obstruction where it is so important to place the tip of the rubber catheter downstream in order to catch the intestinal contents pushed upward by the reverse peristaltic movements.

*The Appendix.* Keeping the lower root of the mesentery in mind as the point of the ileum with the cecum, the appendix can be readily found and delivered into the wound. This lessens trauma to the adjacent intestine and hence makes a more comfortable convalescence.

The abdomen is opened through a muscle-splitting incision. By a cat's pawing action of the first and second fingers of the left hand the cecum is lifted from the iliac fossa. When the cecal head is located the fingers sweep along the iliac vessels in an inward and upward direction describing a quarter of a circle until one feels the band of the mesenteric root. The base of the appendix, if lying free in the abdomen, should be within three-quarters of an inch from this point. If the hand is raised anteriorly and the fingers moved about, the appendix can usually be found. Grasped between the two fingers it can be delivered into the wound. In a right rectus or mid-line incision it is located by sweeping the fingers in an opposite direction. This method is only successful when the appendix lies free within the abdomen.

*The Colon.* The first prerequisite to all surgery of the colon is adequate mobilization of the affected segment so that it can be either exteriorized or resected as the condition requires. With the proper pre-operative preparation and the use of the

newer sulfonamides we believe that open resection and anastomosis is usually the procedure of choice. The entire right half of the colon can be easily freed to the mid-line by incising along the reflected peritoneal line lateral to the ascending portion and the hepatic flexure. Particular care should be taken in protecting the retroperitoneal portion of the duodenum. In a similar manner the splenic flexure and the descending colon can be completely mobilized. In either instance the blood supply will not be disturbed. If a good-sized segment of intestine is to be removed, the operation is simplified by first ligating the vessels at their central position near their points of origin.

The second prerequisite for operations with safety on the colon is accurate serosa-to-serosa suture and the maintenance of an adequate blood supply to the very ends of the cut intestinal walls. It is therefore necessary to remove all fat tabs which come within the first row of serosa-to-serosa sutures. Before completing the anastomosis the question of an adequate blood supply can be definitely answered by severing one of the epiploic appendages near its base. If the cut surface bleeds actively, the circulation to the limb is unimpaired. If it does not bleed, the anastomosis cannot be made with safety and further resection must be done. In carrying out this simple, effective test, care should be taken not to clamp and elevate the appendages so that the long terminal arteries are tented and severed. These arteries are the only blood supply to the outer one-third of the colon wall.

Steward and Rankin have shown that the mesocolic two-thirds of the colon wall has a better blood supply than the outer third. When the colon is to be cut across as for end-to-end anastomosis, a larger part of the vascular mesocolic portion should be reserved than of the less vascular mesocolic one-third. This is achieved by cutting the colon at an angle, not too acute, so that the two ends are equal in diameter.

This also has the advantage of making the anastomotic stoma larger.

*The Rectum.* The posterior part of the one-stage abdominoperineal resection is simplified by thoroughly mobilizing the distal segment down to the tip of the coccyx. Keeping well above the growth, excess colon in the distal segment is excised between two rows of clips inserted by the stitching machine. The stump, which is covered with a rubber glove and securely tied, is turned back into the hollow of the sacrum before the new pelvic diaphragm is completed. It is then met as soon as the membrana propria of the pelvic fascia has been incised after making the posterior entrance. The stump is delivered into the wound and is removed from above downwards thus affording safety and better protection to the prostate gland and seminal vesicles, or to the vagina.

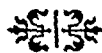
The abdominal wound occasionally contains a subcutaneous collection of serum. Rather than opening the incision with blunt forceps and encouraging wound infection it is better to aspirate the serum with a fine intramuscular needle. This method is also preferable in removing collections of serum which not infrequently occur after mastectomy and thyroidectomy.

#### SUMMARY

Good anesthesia is essential to proficient surgery. The advantages of certain operative positions and incisions have been emphasized. Particular stress has been placed upon the importance of minimizing surgical trauma and methods of accomplishing this have been suggested. A few anatomical points of considerable importance and not generally appreciated have been restated. A number of practical maneuvers that have been found helpful in surgery of the abdomen have been described.

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# CICATRIZING ENTEROCOLITIS\*

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ANY disease which we are unable to fit into a chronological pattern in which etiology, symptomology, pathology and treatment follow each other in regular order is a challenge and stimulant to the doctor. In such categories are cancer, some of the virulent virus infections and poliomyelitis. Other diseases become a symptom complex rather than a well ordered entity. Cicatrizing enteritis is such a disease. One source of medical progress is by means of a pooling of knowledge. All who work on a disease acquire some ideas and their thought processes, by repetition or perhaps by stimulation of others, may in time result in a complete knowledge of the condition which we are endeavoring to study.

Chronic cicatrizing enteritis is not a new disease, nor has our knowledge of such a disease been acquired just recently. Abercrombie and Saunders described it quite as we know it today. As early as 1806, before the Royal College of Physicians in London, Holms reported a fatal case. It was not until the 1930's, however, that a complete summary of the entity as we know it was prepared. In this preparation the accurate, excellent description and recognition of the disease as a complete process was due to the epochal work of Crohn, Ginsberg, and Openheimer in 1932. Lick, in 1938, selected 497 cases from the literature and an even larger number have been presented from time to time since then.

In spite of all the work that has been done, we know very little still of the etiology, and the treatment is a matter of great conjecture between the internist and the surgeon and even among the surgeons

themselves. A review of the literature and our own experience with sixteen patients operated on in a Naval Hospital has shown that the final word on treatment is far from written.

All efforts to find one etiological factor or organism as the cause of this disease are ineffectual. For many years the tubercle bacillus was given the ignoble credit, mostly because no predominant organism has been discovered and the granulations present were not unlike those in tuberculosis elsewhere in the body. Cultures of the peritoneal cavity and of lymph glands removed at operation, have in most cases, been sterile. In a few instances the streptococcus has been found and in one of Mixter's cases a pure culture of anaerobic streptococcus was reclaimed. It seems clear that if some organism is the cause of this disease it is one of the filterable virus group or some organism which in symbiosis with the colon bacillus becomes extremely virulent. It is significant in our mind that 90 per cent of the disease arises in or involves the ileocecal area. In a fairly high percentage of the patients, the appendix had been found diseased. In a series of six appendectomies, operated on by the author in which the appendix was primarily and acutely inflamed, concurrent petechial-like stipling of the cecum and ileum was present, with the reddened streak-like vessels stretched across the bowel. The characteristic induration of the bowel and the enlarged glands were also noted. We believe these lesions, if continued, would develop into a chronic cicatrizing enteritis. It follows that in these instances the inflammation in the appendix caused mesenteric adenitis and secondarily pro-

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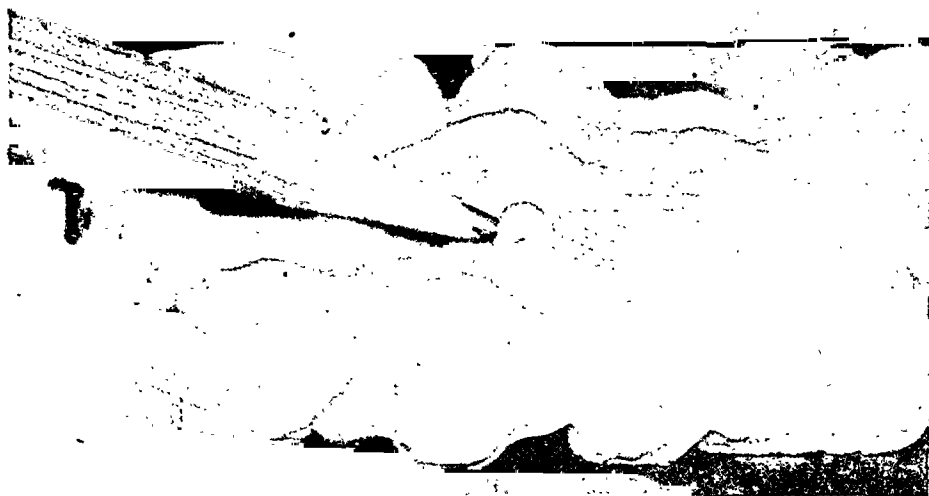


FIG. 1.



FIG. 2.

FIG. 1. Lesion involving the ileum, cecum and ascending colon. Pointer placed in point of perforation.

FIG. 2. Thickened bowel wall and mucosa with ulcers present. Lumen had decreased to one-third normal size.

duced an inflammation in the lymph ducts with lymphedema. If the process had continued, inflammation would have reached the granulation stage, with later fibrosis. All surgeons have had the experience of finding an acute enteritis instead of, or in addition to, an acute appendicitis. In most instances an appendectomy has been performed. In some instances, surgeons have not removed the appendix when the enteritis was discovered, fearing the development of a fistula. In many of these, the disease progresses despite medical management. Regardless of whether the appendix, itself is the source of inflammation which results in lymphadenitis in the mesenteric glands, we are all in agreement that the enlarged nodes develop. A lymphatic block then follows

with brawny indurated areas in the mesentery and bowel, not unlike the brawny induration in the lymphatic stasis anywhere else in the body. The lymphatic block, in lymphedema of the limb (so-called elephantitis), is characterized by high fever, chills, redness and inflammation of the part involved. A lymphatic block in any part of the body causes repeated acute exacerbations, and in the abdomen, the lymphadenitis and edema of the intestines could well produce the cicatrizing end effects that we see. Freedom from inflammation could give us the remissions, and fibrosis of the lymphatic channels could cause the skip effect so frequently seen. In our opinion, the acute lymphatic block and secondary swelling and edema in the involved bowel with periods of remission,



FIG. 3. Abdominal sinuses present in patient with advanced lesion; lipiodal injection of sinuses.

closely follows the condition seen in other parts of the body when there is an acute

tive state. Eventually, this results in so much scarring in the appendix wall, that the trauma of an operation and the poor healing incident to the lymphatic block results in the fistula so frequently seen. Too much effort has been made to separate such conditions as terminal ileitis, ileocolitis, cicatrizing colitis and certain groups of ulcerative colitis. Many cases of ulcerative colitis, certainly of the non-specific type, will go into these so-called cicatrizing enteritis conditions and in addition to the ulcerations of the mucosa, there will be thickening and induration and granulation changes in the mesentery and bowel wall. In patients with ulcerative colitis, perhaps; the acute ulcer may cause lymphadenitis.

#### SYMPTOMOLOGY

The symptoms of inflammation of any part of the small or large bowel extending from an acute stage through chronic and complication stages may be so bizarre that no symptom description can be com-



FIG. 4. X-ray showing so-called "string sign"; a late stage in the disease.

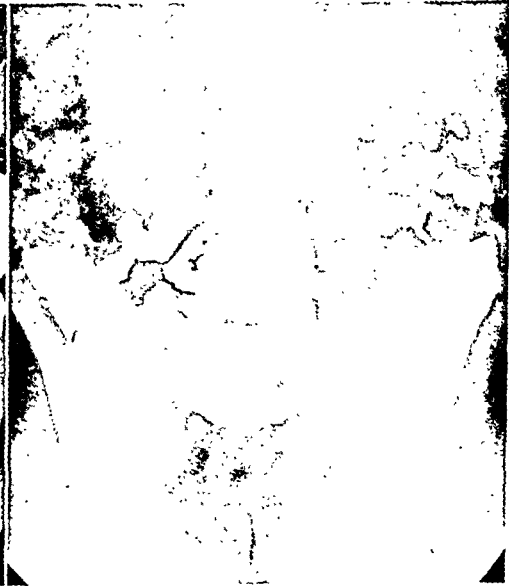


FIG. 5. X-ray showing alteration in the mucosal patterns, constriction and partial obstruction with hypermotility.

lymphatic blockage. We believe that the most likely original source of this infection is an appendix which chronically becomes inflamed in a low grade and non-obstruc-

plete. One patient complained of cramps for eighteen months while another presented symptoms only when he had an acute perforation of his cecum and fecal

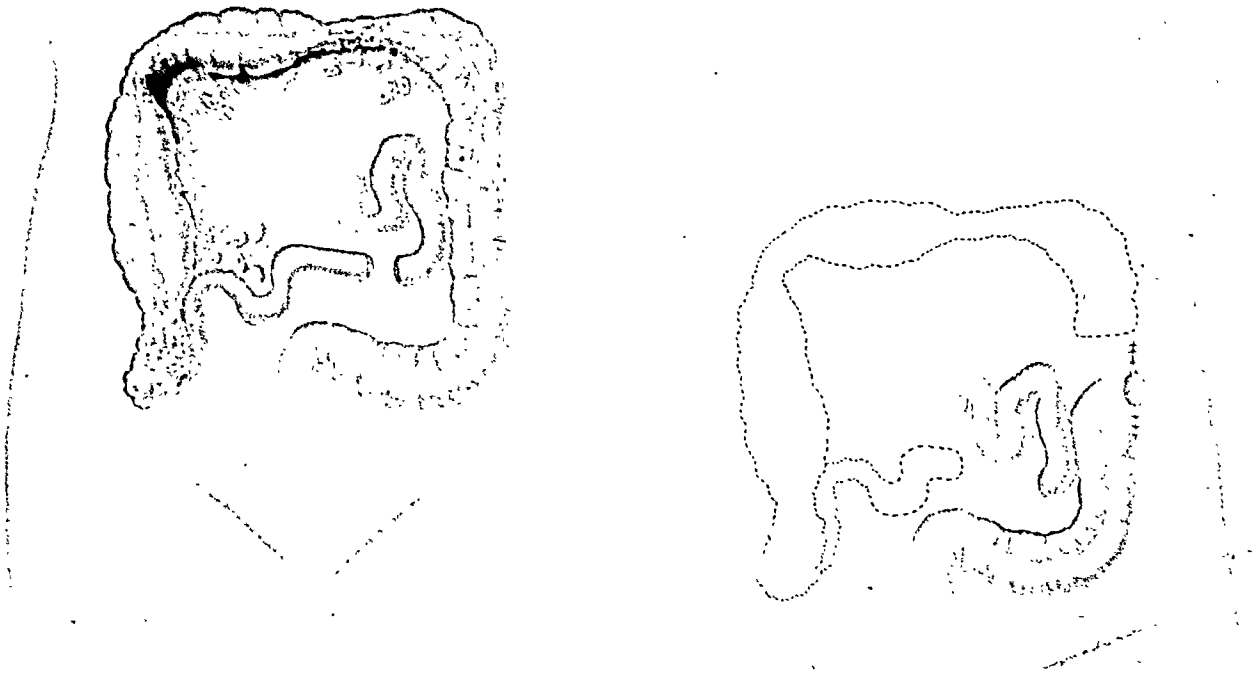


FIG. 6. Stages of surgical treatment of cicatrizing enterocolitis. Exclusion operation performed. Note: Appendix previously removed in first stage. Drawing also shows excision of diseased bowel with temporary colostomy; third stage of disease.

peritonitis, these latter symptoms being of four hours' duration. A simple three-stage classification, the first or acute stage, second or chronic, and third or complication stage simplifies the symptomatology.

*First Stage.* In most cases the early symptoms will be those of peritoneal irritation which is often diagnosed as acute appendicitis. This includes fever and right lower quadrant pain and tenderness and there may be some leucocytosis. If an appendectomy is performed and the disease is not too far advanced, there may be no further symptoms. If the disease is advanced, a chronic enteritis will develop.

*Second Stage.* The second group of patients are the ones with more advanced symptoms, not unlike ulcerative colitis with cramp-like pains, at times loss of weight, and in one out of three, diarrhea.

The x-ray findings are suggestive in this second stage with some dilated loops, fluid wave, hypermotility, change in the mucosal pattern, and loss of haustrations. There may be some encroachment of the lumen.

*Third Stage.* In the third or complication stage a complete or partial obstruction

may develop. The symptoms then are cramp-like pain, vomiting and distention. While obstruction is supposedly rather rare, one-third of our patients were operated upon because of intestinal obstruction. It is in this third stage that the x-ray finding of a "string sign" appears. This is an extremely late sign in the disease, the other signs being distended loops, a loss of haustration and fluid waves in the loops. Fistulas, particularly around the anal region, are not unusual. Every patient with a fistula, who has any abdominal complaints, deserves study on the presumptive diagnosis of enteritis inasmuch as one out of every three patients with this condition develops a fistula. Sinus formation or perforation is a stage of complication of the disease and may be terminal.

Physical finding on these patients depends entirely upon the stage of the disease. In the initial stage, the right lower quadrant tenderness is predominant and again brings up the ileocecal character of the disease. There may be tenderness along any of the involved loops and distention of these same loops with tym-

pany. Sixty per cent of our patients showed a weight loss of from 16 to 35 pounds while in two there had been no weight loss at all. X-rays may show fluid levels when obstruction is developing and there may

and under microscope that the findings may be diverted readily by one's interests. Microscopic sections in the early stage are rarely available for study, as surgeons do not resect in the acute stage. In the sec-

TABLE I  
THREE STAGES OF CICATRIZING ENTERITIS  
FIRST STAGE

Symptoms	Pathology	Diagnosis	Treatment	
			Medical	Surgical
Irritated peritoneum Simulate acute appendicitis R. L. Q. pain and tenderness Vomiting Elevated W. B. C.	Angry injected bowel wall with punctate petechiae-like areas on serosa Some edema Usually iliocecal area Enlarged mesenteric glands	Made at operation for acute appendicitis X-rays usually negative	Dietary Sulfa and penicillin Removal of foci of infection Supportive vitamins, etc.	Appendectomy

Prognosis: Most Subside—few go on to second stage.

TABLE II  
THREE STAGES OF CICATRIZING ENTERITIS  
SECOND STAGE

Symptoms	Pathology	Diagnosis	Treatment	
			Medical	Surgical
Simulates ulcerative colitis Cramp-like pains Occasional distention Diarrhea in $\frac{1}{3}$ to $\frac{1}{2}$ of patients —loss of weight Weakness Anemia	Granular Thick, sticky bowel with very large mesenteric lymph nodes Skip areas	Made on symptoms and x-rays showing loss of haustration Hypermotility some distended loops Slight encroachment of the lumen	Supportive Dietary Chemotherapy Vitamins Blood transfusions	If medical treatment fails, bi-passing operation, i.e., ileocolostomy with exclusion

Prognosis: Most (perhaps 50%) subside.

be a mass at any point of obstruction. The symptoms of perforation or sinus formation are obvious.

#### PATHOLOGY

The pathological picture is as diverse as are the symptoms. The description by two pathologists may vary. There are so many findings at the pathological table

and stage, the thickened and edematous bowel is found with a granular and petechial hemorrhage effect on the serosal surface and an indurated and thickened mesentery with large glands that are frequently matted together. A stickiness to the serosal surface and a tendency of the loops to adhere to each other may also occur. There may be ulcers in the mucosa.

TABLE III  
THREE STAGES OF CICATRIZING ENTERITIS  
THIRD STAGE

Symptoms	Pathology	Diagnosis	Treatment	
			Medical	Surgical
Obstruction signs with pain, cramps, and distention Diarrhea Sinus or fistula formation in $\frac{1}{3}$ with drainage Weight loss weakness	Matted obstructed bowel with encroachment of lumen Thickened walls Enormous lymph nodes At times ulcerated mucosa "Garden hose" type of bowel	On signs of complications X-ray shows fluid wave Distended bowel "string sign" (late)	None, except supportive to surgical	Resection of obstructed bowel  Resection of sinuses and fistulae At times colectomy

Prognosis: Collected mortality 14 to 30 per cent.

TABLE IV

Patient	Age	Entrance Complaint	Examination	Hgb.	RBC	WBC	Wt. Loss	Hosp. days	Treatment
1	44	Abdominal pain—17 days (pelvic abscess after appendectomy 3 yrs. prior)	Pain and tenderness Tympany	91	4,8	11,5	16 lbs. 18 mos.	180	Drainage of abscess and sinus
2	22	Umbilical pain Diarrhea	Pain and tenderness—R. L. Q.	94	4,8	12,1	Few lbs.	90	Resection
3	18	Pain, vomiting, distention	Rigid abdomen	104	5,4	9,2	None	70	Resection of cecum and part of ileum
4	20	Pain and fistula	Sinus tract Some distention	80	4,3	16	25 lbs.	170	Excision of sinus
5	30	Abdominal cramps, severe	Distention Tenderness	81	4,4	14	None	90	Resection
6	20	Fistula—18 mos. 3 times recurrent	Fistula—sinus pain	98	4,7	15,5	35 lbs. 18 mos.	130	Resection
7	21	Cramps—weakness Fistula	Fistula	50	3,5	7,4	Slight	120	Resection
8	21	Pain, cramps, diarrhea	Small mass Tenderness	88	5,4	7,5	17 lbs.	270	Ileosigmoidostomy Resection
9	30	Pain, cramps, diarrhea	Distention Tenderness	94	4,8	10	15 lbs.	70	Ileosigmoidostomy
Average	25	Pain 100% Diarrhea 33 $\frac{1}{3}$ % Fistula 33 $\frac{1}{3}$ %		86%	4,5	11,4	13	132	66% Resection

Mortality = 0



The layers of the bowel wall are thickened and well defined and the disease shades off as a more normal bowel is reached. In the later stage, the bowel becomes rigid and the term "garden hose" is descriptive. The loop becomes narrow as scarring takes place. In one of our patients we were unable to insert the finest probe through the lumen left by the scarring. With obstruction in the complication stage the pathological picture includes edema, a marked leucocyte infiltration, necrosis of the wall, and finally perforation. Edema and necrosis with surrounding scar formation is a finding in the area of a sinus or fistula.

#### TREATMENT

In the past there has been as much disagreement on the treatment between internists and surgeons and among surgeons, themselves, as there has been on the etiology. From this disorder a logical and quite successful program of therapy may be drawn up. In the *first stage* it is usually impossible to differentiate the symptom from that of acute appendicitis, so that the diagnosis is usually made definitely at the operating table. Many authors oppose an appendectomy at this time because of the possibility of fistula formation. Fistulas occur at times without operation and we believe that once the abdomen is open, the appendix should be removed. Its retention may be of etiological consequence in keeping the disease active. Extra care should be taken in the technic at removal of the appendix, avoiding crushing of the base and other trauma. Fallis reported seven appendectomies during the acute stage with five of the seven remaining well thereafter. On follow-ups none of the six patients we have operated has developed further symptoms.

Medical treatment thereafter is as important as surgical treatment. This treatment should include dietary care, bowel management, the elimination of foci of infection, and sulfa and penicillin therapy during the acute stage. X-ray study at

periodic intervals thereafter should be made.

There is disagreement as to therapy, too, in the later stages of the disease. That the therapy is surgical is now admitted and the delay in transfer of these patients from the medical to the surgical service is usually because of a missed diagnosis. If the lesion continues despite a carefully regulated medical régime of four to six months, nothing further can be expected medically. The by-passing operation of an ileocolostomy with the anastomosis being performed sufficiently proximal and distal to the disease to be free of it with transection of the bowel is the treatment of choice at this second stage. In many instances further operation is not required, the lesion resolving itself completely. This power to resolve itself is unique, the healed lesions not being found post-mortem. Apparently there is no stage of arrest; the disease either progresses or regresses. A medical régime can then be re-established and if the symptoms subside, the patient may then be considered cured. This occurred in one of our patients. Should the disease fail to respond or progress, surgical resection will then be necessary. In the third or complication stage the operative treatment is resection in all instances, as then the relief of a mechanical obstruction is the paramount problem. The resection of the glands in the mesentery is likewise necessary and the extent of the bowel to be resected can best be decided by the extent of the mesenteric gland involvement.

Because of the extent of resection and the frequency in which the large bowel is involved, the resection is most often of the Mikulicz type. This is performed in the acute obstruction stage as a colostomy is established at the operation. In the cleaner ones, an immediate anastomosis can be performed and in our hands a side-to-side anastomosis is most satisfactory. The use of the sulfa drugs and penicillin has greatly increased the number who can be resected, primarily. Where the

disease is advanced, a stage operation can be performed with implanting of the bowel on the abdominal wall in preparation for later resection. In two instances this was done at the same time that the anastomosis was made, thus making the supplemented procedure minimal.

While we had a negative mortality in this series, despite the fact that one was in an acute perforation stage, one cannot expect such figures in larger series. Mixer, in a canvas of twenty-seven surgeons who had operated 278 times on 363 patients, found a gross mortality of 14 per cent. To eliminate this mortality, Garlock, Colp, Cave and others have advocated the sidetracking operations as the only operation necessary and Colp and Garlock reported a series of forty patients so treated without a death. Experiences elsewhere, including our own, show that frequently the disease does not stop and that resection is necessary after all. The procedure, however, as a stage and as a final treatment in some is an excellent plan. Its use is limited to those found in the second stage before obstruction has occurred and those without fistulas or sinuses. The patients with sinuses and fistulas require resection as efforts to repair locally or turn in these sinuses and fistulas usually result in failure due to poor healing and the disease process in the bowel wall. The fistula is usually at the site of considerable disease and its resection is therefore indicated.

#### COMMENTS

In recapitulation, we believe that some infection, most likely in the appendix, causes a marked lymphadenitis in the mesenteric glands with a subsequent or concurrent lymphedema which causes repeated episodes such as are seen as lymphatic blocks in any part of the body. These are characterized by fever, chills with local edema, inflammation due to an organism or organism in symbiosis still unknown.

We believe that there are three stages to

the disease, the *first stage* being that in which the symptoms simulate acute appendicitis, in which the inflammation produces an acute injected petechial-like hemorrhage on the bowel, some edema, and lymphadenitis, the diagnosis being made when the abdomen is open, under the diagnosis of an acute appendicitis. In this stage, we believe that appendectomy is indicated and that a medical régime should then be instituted and followed. The disease, in most of these patients, will subside.

The *second stage* is one in which the symptoms are not unlike an ulcerative colitis, with inflammation, diarrhea in some, cramp-like pains, local distention, and x-rays showing some loss of mucosal pattern and haustrations and, at times, narrowing of the lumen and hypermotility. If three months of conservative treatment does not bring improvement in this second stage, the surgical treatment of choice is a by-passing operation with exclusion of the involved bowel, the anastomosis being performed between loops of bowel entirely free of the disease, as shown by local examination and also by the absence of mesenteric nodes of the involved loops.

The medical treatment at this stage is important and should be continued. A high percentage of patients in this group at this stage will have their disease arrested spontaneously.

We believe there is a time at which so much inflammation and fibrosis in the lymphatics has occurred that regression is no longer possible even though inflammation at that stage or thereafter dies out. In these, the damage has been done, and the ultimate result will be fibrosis and scar formation which will result in obstruction or perforation with sinus and fistula formation or both. This stage we consider as a *third or complication stage* and at this time the treatment is entirely surgical. The treatment then requires resection of the loops of the bowel involved in the obstruction or in the fistulas and sinuses. It is in this stage that the x-rays show the obstructive signs of fluid waves,

distended bowel proximal to the site of the obstruction, and the so-called "string sign." The "string sign" is a very late sign in this disease and is a sign of the complication of obstruction and not a sign of the disease. One should never wait until a "string sign" is present before instituting treatment.

The mortality in this group of patients will vary directly with the length of time the disease has progressed. In those in the second stage in which a by-passing operation can be performed, the mortality should be negligible because the patients are in better condition and the operation to be done is less formidable. Once the complications of obstruction or fistula formation have occurred, the patient is no longer in such good condition. He will be suffering from weight loss and anemia and loss of strength; the bowel to be handled is more friable and the operation to be done considerably more extensive. The mortality then must necessarily be greater. It is not a question of deciding between the types of operations; it is more a question of getting the patient early enough to do the limited operations, hoping that that will be all that is necessary. The surgery in the third stage, no matter how skilled the operator, will always have a rather high mortality. We believe, then, that this disease in nearly all instances runs its

course and dies out. If it subsides before perforation or obstruction occurs, recovery and resolution can be expected.

Large and radical surgery before the disease has run its course is not indicated because skip lesions may occur before or beyond the large resection; loops of bowel not necessarily lost may be resected and later another resection may be required. In other words, resection is not the treatment of choice when the diagnosis is made. It is for the complication stage after the disease has run its course. We make no plea for one type of surgery, only that the operation be selected for the stage in which the disease is found.

Disability will always be prolonged in this disease. The hospital days in our ten patients ran from ten weeks to thirty-six weeks. The preoperative preparation with sulfa drugs and blood transfusion may be of aid in diminishing this time.

#### SUMMARY

1. A review of the known factors of the disease is made.
2. Suggestions on etiology and pathogenesis are presented.
3. Surgical treatment in the three stages of the disease is correlated.
4. Ten advanced lesions and six early cases are described.



# CHLOROPHYLL IN WOUND HEALING AND SUPPURATIVE DISEASE

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THIS paper records the experiences and observations of the author and a group of over thirty officers of the surgical service in the treatment of various clinical cases by the use of water-soluble derivatives of chlorophyll. The studies were initiated as a result of a careful review of various published<sup>1, 2, 5, 10, 16, 19, 24, 25, etc.</sup> and certain unpublished papers covering extensive laboratory and clinical studies on the use of such water-soluble chlorophyll derivatives for therapeutic purposes.

In reviewing this literature, it was apparent that these natural biogenic agents were non-toxic when administered topically, parenterally or by mouth, and that such chlorophyll preparations accelerated healing more effectively than most of the other commonly employed agents used to treat clean and infected wounds.

It was impossible to carry on extensive controls in this study due to obvious limitations in time and the duties of the staff with such a large hospital census. However, it was felt due to the large number of cases in this series—over 400—and the corroboration by more than thirty-five medical officers of the staff of the Winter General Hospital, that the conclusions presented would appear to be convincing. In addition, these studies have been carried on over a period of nine months, a sufficiently long enough period of time to indicate the basic activity of these chlorophyll derivatives as healing agents\* in many diverse types of wounds and injuries. The appearance of bilateral lesions in many instances treated with control preparations, has again shown evidence of the relatively

greater efficacy of the chlorophyll preparations. In many instances, the use of alternate cases has similarly confirmed the effectiveness of chlorophyll therapy.

It does not seem particularly pertinent in a clinical paper of this type to review the extensive literature relating to the chemistry, pharmacology and bacterial action of chlorophyll. However, it may be stated in summary, that solutions and an ointment incorporating the water-soluble derivatives of chlorophyll can now be obtained in uniform, stable form and that they are completely non-toxic. Furthermore, they possess direct antibacterial activity, especially in relation to the secondary saprophytic, proteolytic organisms associated with wound infection, which give rise to the foul odor associated with this type of lesion. The prompt deodorizing of these malodorous conditions by these chlorophyll preparations was particularly noted by the surgical staff especially those in the Orthopedic Section.

The literature has further established the fact that such chlorophyll derivatives are cell-stimulating agents, aiding in the regeneration of tissue and thus indirectly aiding in the control of infection through acceleration of the normal repair mechanism as amplified in the following statement.

*Tissue Stimulating Effect.* The beneficial effect of chlorophyll in suppurative lesions and in aiding wound healing apparently is due, not to inhibitory action on the bacteria, primarily, but rather to a marked stimulating effect exerted on the tissue cells of the host. This is demonstrated grossly by the very rapid formation of unusually firm and fine textured granulation tissue. A review of the literature reveals more fundamental evidence that

\* The water-soluble chlorophyll derivative preparations used in this clinical study have been generously furnished by the Rystan Company, New York, N. Y., under the trade name Chloresium.

chlorophyll is a strong cell stimulant. For example, Gordonoff and Hosokawa,<sup>13</sup> in 1925, showed that an exhausted nerve muscle preparation will contract upon addition of chlorophyll. Grill,<sup>15</sup> in 1923, found that chlorophyll had a stimulating action on the tissues and organs of experimental animals. Burgi,<sup>3</sup> in 1922, Fischer and Schneller,<sup>8</sup> in 1924, Gordonoff,<sup>12</sup> in 1929, Rentz,<sup>18</sup> in 1929, Zih,<sup>28</sup> in 1930, Sagastume and Pezzani,<sup>23</sup> in 1930, and Rothmund and Inman,<sup>21</sup> in 1934, showed the close chemical relationship between chlorophyll and hemoglobin. These various authors also showed the effectiveness of chlorophyll in stimulating red blood cell and hemoglobin regeneration. Koenigsfeld,<sup>17</sup> in 1922, found that chlorophyll ingestion definitely increases the metabolic rate in man while Rydin,<sup>22</sup> in 1928, found that carbon dioxide elimination and oxygen absorption were increased in both normal and thyroidectomized chlorophyll-fed rats. He concluded that chlorophyll was a cell stimulant, increasing fundamental cell metabolism. In 1930, extracts of plant pigment were shown to stimulate tissue growth by Rollet,<sup>20</sup> working with Burgi<sup>3</sup> who has conducted investigations along this line for over twenty years. Gordonoff and Ludwig,<sup>14</sup> in 1935, showed that these extracts have a stimulating effect on growth of tissue cultures *in vitro*. In 1937, Burgi<sup>3</sup> proved that chlorophyll has a far greater tissue stimulating effect than other plant pigments, carotene or xanthophyll. Smith and Sano,<sup>25</sup> in 1944, showed that vitamins B and C, present in plant extracts were not responsible for the tissue stimulation and that chlorophyll in concentrations of .05 to .5 per cent, when added to comparable tissue cultures of embryonic fibroblasts, caused an almost immediate growth response with elimination of the usual six to eighteen-hour lag period. They demonstrated that this growth stimulating effect can be maintained by replenishing the medium with chlorophyll every forty-eight hours. Smith and Livingston,<sup>24</sup> in 1943, found that chlorophyll, used on

experimental wounds, caused an average of 25 per cent acceleration of healing as compared with other agents alleged to have a similar effect. Clinically, we have found that the very rapid stimulation of granulation tissue, induced by chlorophyll dressings, has been a disadvantage in certain plastic cases and particularly in burns, in which the profusion of granulation tissue interfered with the procedure of skin grafting. Now we use chlorophyll in such cases, only until the wound is clean and odorless, then we use such a dressing as vaseline or xeroform gauze with pressure bandages. In the orthopedic cases, it usually is possible to continue the use of chlorophyll until complete wound healing has been attained.

*Drying Effect.* An outstanding feature in the use of chlorophyll has been the fact that in abscesses, empyema cavities, sinus tracts, surface lesions and osteomyelitic cases, the purulent drainage has stopped within forty-eight to seventy two hours. This also has been true in the eye, the nose, accessory nasal sinuses, lesions about the mouth and in purulent infections of the urinary bladder or kidney pelvis. This finding has been consistent, if the chlorophyll can reach the site of origin of the pus, and only a slight serous discharge is seen after that time. We offer no good explanation as to the mechanism of this action of chlorophyll.

*Deodorizing Effect.* Chlorophyll was first used at Winter General Hospital in a group of compound fracture cases with osteomyelitis and widely open wounds. These patients had been draining profusely for months and were so malodorous as to deprive patients and attendants of appetite. Personnel passing down adjacent corridors also made unfavorable comment on the very pervading and unpleasant odor. Our first observation on beginning use of chlorophyll was that this odor immediately disappeared, and next we observed a great improvement in appearance of the wounds with marked acceleration of wound healing. Soon, other patients in neighboring

beds began to request treatment with the "green medicine" because they, too, observed the rapid progress after months of drainage and odor. In our hands, chlorophyll has been far superior to penicillin in deodorizing wounds. This lack of bad odor in the "bone infection" wards has been a matter of spontaneous comment by U.S.O. show troupers who have been accustomed to the bad odor of such cases in this country and abroad.

*Ephedrine-like Effect.* When used as nose drops, the buffered chlorophyll nasal solution has uniformly and quickly overcome the nasal obstruction accompanying acute coryza and sinusitis. There has been absence of the undesirable secondary swing seen following the use of ephedrine. The effect of chlorophyll is too soon to be on the basis of bacteriostasis or drying effect although subsequently nasal discharge ceases. The mechanism of action of chlorophyll in these cases is not known but it has been pointed out that the cell-stimulating effect of chlorophyll may cause normal ciliary action to return and thus aid in drainage.

*Chlorophyll plus Penicillin.* From the earliest recorded days of medical history, men have searched for the magic drug which would destroy bacteria but would not harm the tissue cells of the host. Penicillin follows the traditional chemotherapeutic approach of attack on invading bacteria, whereas chlorophyll typifies a new approach, namely, stimulation of the cells of the host so that they may deal with the invading organisms. Smith,<sup>27</sup> in 1945, was the first to recognize the logic of combining these two principles and he first suggested the use of penicillin in chlorophyll. He has shown experimentally that induced infected wounds treated with 1 per cent chlorophyll ointment healed in 14.3 days, whereas local application of penicillin caused healing in fifteen days while penicillin in chlorophyll produced healed wounds in 10.6 days. In a number of cases, we have used a solution of 250 units of penicillin per cc. of chlorophyll solution as a wet dressing. We are

the first to report the clinical use of this combination of agents but as yet our experience is too limited to permit of definite conclusions. However, we have been eminently pleased with the results of chlorophyll alone; and with our present gross methods of clinical evaluation of wound healing, we are unable to state that the mixture is any better than chlorophyll alone. We believe very definitely that penicillin is not as effective as chlorophyll in cleaning up a wound, rendering it odorless and promoting rapid healing. Penicillin is limited in scope because of its specificity for certain bacterial groups, whereas chlorophyll is widely applicable because of its more fundamental action of tissue stimulation.

#### USE OF CHLOROPHYLL IN CLINICAL CASES GENERAL SURGERY SECTION

One hundred one cases are here reported.

*Pilonidal Cyst Wounds.* Nineteen cases comprise this group. Of these cases, two failed to show any particular response to chlorophyll, sulfanilamide powder, cod liver oil or dry dressings. Another patient was operated upon overseas and was evacuated here with a non-healing wound of nine months' duration. This wound was foul and the granulations were grayish-red, friable and covered with exudate. Within forty eight hours after use of chlorophyll solution as a continuous wet dressing, these granulations were odorless, clean and of a healthy red color. This wound was healed and the patient went to duty in two months. In one complicated case with five skin orifices, in which wide excision and De Prizio closure was done, healing with chlorophyll dressings was very dramatic but the entire area broke down while the patient was on furlough. A scrape skin graft followed by more chlorophyll dressings gave a complete and satisfactory secondary healing in this very heavy patient. In seven cases, the ointment alone was used; and in all the remainder, wet dressings were used until the wound was nearly healed and then the ointment or

jelly was employed. In the nineteen pilonidal sinus cases, two showed no response while the other seventeen healed better and more rapidly than by other methods previously employed. No definite figures are presented because of the well known tendency for figures to prove any point under discussion but these results were followed closely and critically by six Medical Officers.

*Fistula-in-Ano.* In six cases, chlorophyll solution was used as a continuous pack wet-dressing postoperatively, with very rapid and satisfactory wound healing in all. In one case, a very large post operative defect was entirely healed in fourteen days.

*Tumor Clean-up.* Four cases make up this group. In one case, a sarcoma of the inguinal region, having received maximum x-ray therapy elsewhere, was transferred here with a secondarily infected granulating mass in the groin. With chlorophyll dressings, this area healed; and the patient was discharged to Veteran's care. In a second case, the patient was evacuated from overseas with a destructive lesion of right eye and maxillary sinus, with sloughing, foul skin lesions. These lesions, as well as the orbit and sinus, were rendered clean and odorless within forty eight hours with chlorophyll dressings contributing greatly to the comfort of the patient who subsequently expired. Autopsy revealed an atypical Hodgkin's disease. In a third case, a huge ulcerating carcinoma of the inguinal region was rendered free of secondary infection by chlorophyll packs and the patient was sent to an x-ray therapy center. The fourth case, was one in which there was a metastatic carcinoma of the lymph nodes of the neck from a lip lesion involving the floor of the mouth and mandible. A hemisection of the mandible with excision of the floor of the mouth, block dissection of the neck and much involved skin left a huge defect with the pharynx widely exposed. This defect promptly closed with chlorophyll dressings and the patient was

transferred to an x-ray therapy center. In these cases, the tumor was not influenced but removing secondary infection or stimulation of wound healing were important adjuncts in treatment.

*Ulcerative Colitis.* In one patient with severe ulcerative colitis, chlorophyll solution was used as a continuous drip irrigation of the colon through the ileostomy for several days. Although chlorophyll *in vitro* showed a noticeable bacteriostatic effect on organisms from this case, the course of the disease was not altered and the patient died of multiple spontaneous colonic perforations three and one-half weeks after ileostomy. In spite of this failure, it seems advisable to try this medication in other cases of colitis, either as a rectal instillation or through an ileostomy. No other cases have been available here.

*Thoracic Empyema.* Nine cases of empyema or its residuals make up this interesting group. Two patients with short residual sinus tracts and one after sequestrectomy for rib osteomyelitis promptly healed with chlorophyll dressings. One patient died of bronchiectasis, multiple lung abscesses, thoracic empyema and a subphrenic abscess. Chlorophyll was not equal to this clinical test although the empyema cavity which was being irrigated with chlorophyll was quite clean. Another patient had a bronchopleural fistula in a chronic empyema cavity of about 200 cc. capacity. Chlorine solution irrigations caused severe coughing, but chlorophyll was not irritating and is credited with the prompt closure of the cavity without operative procedure, other than the original rib resection done elsewhere. Two other patients with chronic empyema were treated in this series. One died six weeks after completion of a stage thoracoplasty of brain abscess with meningitis, and autopsy showed a small residual cavity which was clean and would have healed. The other patient with such heavy calcification of the pleura that rib shears and rongeur were required to cut it, healed well with chloro-

phyll irrigations after thoracoplasty and was discharged from the service. The next two cases of acute empyema are particularly interesting because the very rapid healing can be shown clearly by measurements of the cavity. In each instance, all concerned were astonished to observe that within forty-eight hours after rib resection and institution of chlorophyll irrigation of the empyema cavity, purulent discharge ceased. In one of these cases, acute post-pneumonic empyema developed on June 17, 1944, and rib resection was done on August 1, 1944, elsewhere with packing of the cavity with five yards of gauze. On August 28, 1944, the patient was transferred to this hospital and the gauze packing was removed. The size of the cavity was reduced in a period of one month from 120 cc. to 1 cc. The other patient was extremely ill on admission with bilateral hematogenous lung abscesses following tonsillectomy and unilateral secondary empyema. Rib resection was done and the cavity measured 240 cc. Similarly, this cavity was reduced in a period of five weeks from 240 cc. to 5 cc.

*Gunshot Wound Sinus Tracts.* In seventeen cases, gunshot wound sinus tracts involving the abdomen or deep soft tissues elsewhere have been treated by chlorophyll solution injected through a catheter. One of these patients was admitted with a lumbar abscess secondary to a gunshot wound. Cultures of pus from this abscess showed the presence of *Bacillus subtilis*, *Staphylococcus albus* and *Streptococcus viridans*. Daily irrigations with 2 ounces of chlorophyll solution showed the decrease in size of the cavity. In six other cases, multiple deep sinus tracts of soft tissues of the abdominal wall, back or perineum were similarly treated. One case was first subjected to curettement of the tracts but the other five healed by irrigations alone although they had previously been draining for over eight weeks. In one instance, the pus showed *Escherichia coli* and this lumbar abscess healed more slowly than

the others. In three other cases, intra-abdominal abscesses were irrigated with chlorophyll solution through a catheter and these healed within two weeks without further operation. The other three cases are worth individual mention. In one, multiple sinus tracts of the right lower quadrant and groin complicated a cecostomy for abdominal gunshot wound. The cecostomy was closed and the tracts healed with chlorophyll irrigations alone. In another case, operation overseas for gunshot wound of the liver resulted in a cutaneous biliary fistula which drained for over eight weeks. Here again, chlorophyll irrigations caused cessation of drainage and healing of the tract in six days. This soldier was still well after a three-week furlough and was discharged from the service. The final patient in this group was admitted with an hour-glass deformity of the stomach from gunshot wound, the stomach measuring 1 cm. in width in the strictured area. In addition, there was a draining fistula, diagnosed as pancreatic in origin. Irrigation of this tract was followed by complete healing in seven days; and on return from a three-week furlough, x-ray examination showed that the hour-glass deformity of the stomach, upon which we had expected to operate, had completely disappeared leaving perfectly normal gastric function. In another patient, removal of an intra-abdominal mass of cloth was followed by a high jejunal fistula through which food extruded. The eroded skin was comfortable after chlorophyll and within ten days the jejunal fistula and wound were solidly healed. In another instance, a gunshot wound through the ilium was followed by formation of a huge pseudocyst, extending half way down the thigh and almost filling the pelvis retroperitoneally, due to rupture of the ureter. Nephrectomy was done and the huge pseudocyst was irrigated with chlorophyll. It promptly closed. In the final case, a machine gun bullet through the sacrum perforated the rectum just below the peritoneal level. The patient



passed gas and feces through the sacrum till a diverting colostomy was established. Irrigation of the sinus through the sacrum has led to progressive healing and it is anticipated that complete healing will take place without further surgery other than to close the colostomy.

*Perineal Cavity.* In one patient, who had a one-stage combined abdominoperineal resection for carcinoma of the rectum, the perineal cavity was irrigated daily with chlorophyll. This large cavity was clean, odorless and healed in two weeks.

*Burns.* Four patients make up this group. Two officer patients from the same airplane accident were admitted with extensive and severely infected second and third degree burns of the head and both hands. The most severely burned hand in one case and the better hand in the other case, were treated with continuous wet dressings of chlorophyll, while the other hands were treated with boric solution similarly used. In both cases, the patients volunteered the information that the chlorophyll treated hand was more comfortable. The chlorophyll hands produced granulations of better quality and more rapidly so that the worst hand, treated with chlorophyll, soon looked better than the less severely burned hand, treated with boric solution. In both instances, the final result after grafting has been better in the chlorophyll treated hands. In two other cases of infected burns, the odor and discharge stopped within forty-eight hours and granulation progressed rapidly. One of these cases involved the neck and hands while the other involved the trunk and thighs.

*Gunshot Wounds of Foot.* In ten of these patients, chlorophyll solution has been used. In six of these cases, healing has been satisfactory although the wounds were particularly foul and sloughing originally. These were clean and odorless in forty-eight hours. In four instances stimulation to healing has not been better than with other agents. In these four

cases, the slowly healing area is in the region of dense scar tissue which is firmly bound down to underlying structures. Excision of these scarred areas with pedicle skin grafts probably will be required to effect satisfactory healing.

*Plastic Cases.* Six cases comprise this group. A German POW, whose hand was caught in a wringer, came in with avulsion of the soft tissue of the fingers of one hand and gangrene. This hand was cleaned up with chlorophyll dressings and amputation of necessary digits was carried out. A soldier with a large lesion of coccidioidomycosis over the tibial shaft was subjected to electrocautery excision and 100,000 units of penicillin were used to soak the dressings which were not changed for three days. The wound then was perfectly clean but there had been no apparent formation of granulation tissue. Chlorophyll dressings then were employed to obtain a suitable granulating bed for skin grafting. In one patient, outlining, raising and replacing of a skin flap in stages on the thigh for future use was followed by loss of the entire flap. Chlorophyll dressings soon produced a bed of healthy granulations on which a subsequent skin graft took well despite the diagnosis of Buerger's disease and demonstrated poor healing qualities. In two other patients, chlorophyll solution was used to produce a granulating bed for subsequent grafting. One was an old and difficult burn case who took grafts poorly and the other was for a large defect on the back of the neck following removal of an infected keloid for the third time. This latter case healed so rapidly that grafting was not necessary. An officer who had a denuded area occupying the whole left side of the trunk was admitted with a badly infected wound. The patient was treated with saline dressings because it was feared that chlorophyll would cause too many granulations. This patient was very uncomfortable and complained bitterly of the stinging sensation in the wound. Intramuscular penicillin was given in therapeutic doses and eventually the wound

was covered by postage stamp grafts. Local penicillin solution then was applied as a wet dressing and the patient complained more than before of the discomfort. On changing the dressings, it was noted that there was considerable pus, that the granulations were gray and friable and that the grafts were not growing but simply were floating on the surface from which they could be picked off readily. It was thought that these grafts were all lost. At this point, wet dressings of chlorophyll were started and the dressing was changed three days later. To the surprise of several medical witnesses, there was no purulent discharge, no odor and the granulations looked firm and red. The postage stamps were firmly adherent and around each there was a narrow halo of new epithelium. Not a graft was lost. This case finally convinced several officers who had been skeptical of chlorophyll previously.

*Decubitus Ulcer.* Only four patients have been treated but results here have been excellent. Three of these cases healed well and need no comment. The fourth

Measurements on this ulcer were as follows: June 2, 1944, 2.5 by 1.9 inches in diameter, 1 inch deep, undermined .5-.75 inches; June 22, 1944, 2.25 by 1.7 inches in diameter, .25 inch deep, no undermining; July 8, 1944, 2.25 by 1 inch in diameter, .25 inch deep, no undermining. This patient twice hindered his progress on June 11, and July 6, traumatizing this sacral decubitus so that a large hematoma formed under the granulations and adjacent skin. This same patient had a pressure ulcer over the left lateral malleolus which was treated with chlorophyll. Measurements on this showed: June 7, 1944, .75-1 inch in diameter; July 8, 1944, .25 inch in diameter. These ulcers were cleaned in an unusually short time and it is believed that their rate of healing was quite rapid in a paralyzed patient.

*Miscellaneous.* In twenty miscellaneous cases, chlorophyll has been used to stimulate healing in various indolent ulcers and granulating wounds with excellent results. Many other cases currently under treatment with chlorophyll are not here reported.

GENERAL SURGERY SECTION

Diagnosis	No. of Cases	Cured	Benefited	Not Benefited	Method of Rx and Comment
Pilonidal cyst wound.....	19	3	14	2	Ointment or wet dressing
Fistula-in-ano.....	6	0	6	0	Wet dressing
Tumor clean-up.....	4	0	4	0	Wet dressing
Ulcerative colitis.....	1	0	0	1	Irrigation with solution
Thoracic empyema.....	9	6	3	0	Irrigation with solution
Gunshot wound sinus tracts.....	17	17	0	0	Irrigation with solution
Perineal cavity.....	1	1	0	0	Irrigation with solution
Burns.....	4	0	4	0	Wet dressing
Gunshot wounds of the foot.....	10	6	0	4	Wet dressing
Plastic cases.....	6	0	6	0	Wet dressing
Decubitus ulcer.....	4	3	1	0	Wet dressing and ointment
Miscellaneous.....	20	0	20	0	Wet dressing
	101	36	58	7	

case is that of an Italian POW who was admitted with a transverse myelitis and a sacral decubitus ulcer "the size of a silver dollar" with a foul necrotic base.

ORTHOPEDIC SECTION

*Compound Fractures.* Some of the most striking results of chlorophyll therapy have been seen in 119 cases of compound

fractures with osteomyelitis. These fractures have been distributed as follows:

inches in diameter and 1.25 inches in depth. In ten days, good granulation tissue had

Pelvis.....	6 cases	Tibia	50 cases	Small bones of foot	19 cases
Humerus.....	9 cases	Femur	15 cases		
Forearm.....	11 cases	Scapula	1 case	Femur and tibia	3 cases
Femur and humerus.....	1 case	Fibula	3 cases	Femur and forearm	1 case

The wards of patients with battle wounds, compound fractures and osteomyelitis formerly were so malodorous as to arouse comment from individuals passing down adjacent corridors. Within forty-eight hours after beginning chlorophyll irrigations in alternate cases, these cases were odorless and patients in adjacent beds began asking to be treated with the "green medicine." In our hands, chlorophyll locally has been much more satisfactory than penicillin locally or intramuscularly. It seems pertinent to observe at this point that the use of penicillin at this hospital has been one-half to one-third the amount used by other General Hospitals of similar size and treating similar cases. One adjacent Regional Station Hospital uses twice the amount of penicillin used here. This substantial saving in penicillin is occasioned by our wide use of chlorophyll.

In one patient who had a compound fracture of the femur with loss of bone substance and a large through-and-through wound operation was thought to be inevitable but with chlorophyll irrigations the wounds soon closed and new bone rapidly filled the defect. This soldier now has been discharged from the Army. In at least two cases, amputation of the leg was thought to be inevitable by inspectors because of the severe infection but these wounds are healed and dry after chlorophyll dressings. Bone regeneration has progressed so that the patients can be up in a brace allowing weight bearing. Several forearm cases likewise were thought to be amputation candidates, but again chlorophyll caused prompt healing where there had been profuse foul drainage for over six months. In one osteomyelitic case, sequestrectomy of the tibia left a wound .75

filled the wound to .75 inches deep and healing had reduced the diameter to .25 inch. In another patient with a non-healed lower tibial wound following compound fracture a year ago, chlorophyll reduced the wound from 4 by 3 to 2 by  $\frac{1}{2}$  cm. in a month. The wound then was pulled together by adhesive strips and healed. Another interesting case was that of a soldier who in an airplane crash sustained pelvic fracture, ischemic gangrene of the left foot and a tremendous hematoma which was drained elsewhere and which left the entire sacroiliac area bare to the bone. Within two weeks after chlorophyll had been started as an irrigation, the wound had decreased 50 per cent in size and the foul discharge which formerly had ranged between 4 and 6 ounces a day had ceased and the necrotic base had become clean and red. No odor remained after a few days of treatment. The guillotined stump was treated satisfactorily with chlorophyll while in skin traction awaiting transfer to an amputation center.

Interesting observations were made in the case of a soldier who had a metal plate inserted elsewhere for fixation of a compound fracture of the lower third of the tibia and fibula. The wound broke down and the plate subsequently was removed, but the wound failed to heal and a later secondary closure also failed. With application of chlorophyll solution, granulation tissue rapidly grew from the screw holds in the exposed and denuded tibia. Multiple small holes then were drilled through the cortex of this exposed bone, and with chlorophyll dressings, granulation tissue protruded from each in twenty-four hours. These granulations grew well and the soldier was sent on a short furlough. At

home, sulfathiazole ointment was used and all granulations disappeared, leaving white denuded bone again. On his return, chlorophyll treatment caused a prompt reappearance of the granulations. When these granulations had coalesced and had formed a satisfactory bed for grafting, the patient was transferred to a plastic center.

Due to the policy of transferring patients closer to home and to special centers, it has not been feasible to keep figures on healing time in treated and control cases. Neither do we wish to assert that chlorophyll speeds up bone formation as we have not sufficient evidence to prove the point. However, it is our belief that chlorophyll treatment in these cases has saved limbs and shortened the healing period. On the other hand, even if chlorophyll did nothing in these cases but stop odor, decrease suppuration and decrease the need for penicillin, its use would be amply justified.

A large number of patients on the orthopedic section currently are being treated with chlorophyll but no case reports are given here except on closed cases. In sequestrectomy cases, chlorophyll is causing rapid filling of the cavity. In one instance, in which the entire crest of the ilium was removed, closure of the wound took place in less than two weeks. These cases are not included in the tabulation here presented.

#### EENT SECTION

One hundred thirty-two cases are grouped as follows:

*Corneal Ulcer.* Four patients with corneal ulcer have been treated with chlorophyll and the results are tabulated on page 46.

*Keratitis.* This patient was hospitalized six times in six months for recurrent keratoconjunctivitis. Examination showed fifteen to twenty punctate erosions of the right cornea which stained with fluorescein. *Staphylococcus albus* was isolated. The patient was treated with chlorophyll drops four times daily and ointment at night. There were two recurrences at two-week intervals in this hospital and each time the cornea healed in twenty-four hours and the injection disappeared in forty-eight hours. This patient was discharged from the service.

*Conjunctivitis.* In one patient, an acute purulent conjunctivitis of the right eye developed after swimming in a public pool and hemolytic *staphylococcus aureus* was isolated. With chlorophyll drops, the eye was well in four days but recurred a week later after swimming in the same pool. It again cleared in four days with the chlorophyll régime.

*Blepharitis.* A patient with chronic blepharitis of five years' duration showed *Staphylococcus aureus* on culture of pus

#### ORTHOPEDIC SECTION

Compound Fracture	No. of Cases	Cured	Benefited	Not Benefited	Method of Rx and Comment
Pelvis.....	6	0	6	0	Wet dressing and irrigation
Humerus.....	9	0	9	0	Wet dressing and irrigation
Forearm.....	11	0	11	0	Wet dressing and irrigation
Tibia.....	50	0	50	0	Wet dressing and irrigation
Fibula.....	3	0	3	0	Wet dressing and irrigation
Femur.....	15	0	15	0	Wet dressing and irrigation
Scapula.....	1	0	1	0	Wet dressing and irrigation
Tarsus.....	19	0	19	0	Wet dressing and irrigation
Femur and tibia.....	3	0	3	0	Wet dressing and irrigation
Femur and humerus.....	1	0	1	0	Wet dressing and irrigation
Femur and forearm.....	1	0	1	0	Wet dressing and irrigation

Diagnosis	History	Size	Culture	Course
Chr. left.....	1 mo.	2 by .2 mm.	S. albus	Cured in 8 da.
Chr. right.....	3 wk.	3 ulcers	Hem.s.aureus	Cure in 12 hr., 48 hr., and 5 wk.
Ac. left.....	12 hr.	1 by 3 mm.		Cured 4 da.
Chr. left.....	3 wk.	3 by 4 mm.	S. albus	Cured 5 wk.

expressed from the meibomian glands. There was moderate loss of cilia with swollen, red, crusted lid margins showing increased vascularity. He was treated with chlorophyll drops containing 1,000 units of penicillin per cc. of solution using four drops four times daily and chlorophyll ointment at night with expression of the glands every two weeks. In two days, the injection was minimal and remained so with one slight relapse. The meibomian secretion decreased to normal and the patient was dismissed in fifteen days. He stated that his eyes felt better than they had in the past five years.

*Dacryocystitis.* This patient developed severe pansinusitis, right orbital cellulitis and acute cavernous sinus thrombosis overseas. On admission here, there was a draining sinus tract in the nasal portion of the right orbit, the right eye was phthisical, there was a severe symblepharon of the lower lid and there was a profuse foul smelling discharge from the tract. Staphylococcus albus was found on culture. Daily irrigation with chlorophyll solution caused cessation of suppuration and disappearance of odor in forty-eight hours. The sinus tract healed in three weeks, having drained continuously for over four months. This patient later died of an atypical Hodgkin's disease.

*Rhinitis, Acute, Catarrhal.* Seventy-two cases make up this group and the period of treatment varied from six to fourteen days, ten being the average. The method of treatment was instillation of chlorophyll drops two to three times daily or atomizer spray at the same interval. A number of these patients have been medical officers and their families so that a rather close

observation has been possible. It has been noted routinely that instillation of chlorophyll into the nose obstructed by acute inflammation was followed by free breathing in a matter of minutes and drainage was promoted. This shrinkage of mucosa also improved drainage in the acute sinus complications and relieved the vacuum type headache. In 75 per cent of these cases, the nasal discharge remained watery or mucoid and never reached the purulent stage. The use of chlorophyll had no unpleasant side effects such as sometimes seen with ephedrine. One medical officer, whose colds usually progress through sinusitis, laryngitis and bronchitis with cough and headaches for three weeks, had the process stopped at the sinusitis stage in less than a week. Another patient, whose colds always include conjunctivitis in first one and then the other eye with severe laryngitis, had the process arrested after only one eye had been involved. These patients, who have severe colds, which run a rather definite course, all have been impressed with the fact that, using chlorophyll, the duration has been shortened and the complications have been absent or lessened in severity.

*Rhinitis, Chronic, Degenerative, Atrophic.* Nine such patients have been treated by instillation of chlorophyll drops over a period of seven to thirty days. There were no demonstrable changes in the mucosa but the discharge changed from purulent to mucoid, lessened in amount and there was a definite decrease in the odor of these cases. Headache was improved in most instances. Four of these patients would admit no benefit.

*Rhinitis, Allergic.* These two patients obtained relief inasmuch as chlorophyll drops opened up the nasal passages and allowed easy breathing. The patients previously had used ephedrine but prefer chlorophyll. One patient is a medical officer and the other is the wife of a medical officer.

*Sinusitis, Chronic.* Eighteen cases, involving single or multiple sinuses, were treated with chlorophyll drops four times daily. Six of these patients, with antral involvement, did not respond to this treatment and these cases then were treated by the Proetz displacement filling technic, using 15 to 20 cc. of chlorophyll solution every two days. Four of these cases cleared up but two did not respond completely. One had an oromaxillary fistula, and the other was transferred to another hospital because of concomitant battle injuries. The average time of treatment of the Proetz treated cases was fourteen days, while the others were treated for seventeen days. The cases that cleared up are classed as "benefited" because we do not believe that clearing up one bout of chronic sinusitis constitutes a "cure." As controls, some of these patients were treated with ephedrine and others with saline sinus irrigations. Most had had previous treatment for recurrent attacks. The majority of the patients did better with chlorophyll than with the other previously used agents.

*Mastoiditis.* Three mastoidectomy wounds were treated with continuous chlorophyll wet dressings and this stopped suppuration and odor but caused a too rapid increase in granulation tissue, as had been noted also in other areas. One case of bullet wound through the mastoid area with osteomyelitis was benefited by chlorophyll treatment in that odor was ablated and healing followed.

*Otitis Media, Suppurative.* Seven patients were treated with chlorophyll drops instilled into the ear and five of these cases completely dried up and the drums resolved. One case came to simple mastoidectomy with subsequent healing and later recurrence after severe nasopharyn-

gitis. Two patients were treated with chlorophyll containing 150 units of penicillin per cc. but the resultant resolution was no more striking nor rapid than with chlorophyll alone. In all the cured cases, the purulent discharge first became odorless, then became mucoid and then complete resolution followed.

*Otitis Externa.* Eighteen cases make up this group. One of the cases was a secondary dermatitis from irritation by discharge from otitis media. This cleared rapidly. The other seventeen cases were in soldiers returned from the South Pacific Theatre, where this condition is very common and intractable. These patients had received most of the known forms of treatment before coming here and the duration averaged two months. In fifteen of these cases, daily or tri-weekly topical application of chlorophyll as a wet dressing or the ointment, gave healing in an average of twelve days. In one case, the involvement included the entire ear, mastoid region and onto the side of the face. This patient was cured in thirty days. One case of the eighteen did not respond to chlorophyll treatment.

## EENT SECTION

Diagnosis	No. of Cases	Cured	Benefited	Not Benefited
Corneal ulcer.....	4	3	1	0
Keratitis.....	1	0	1	0
Conjunctivitis.....	1	1	0	0
Blepharitis.....	1	1	0	0
Dacryocystitis.....	1	1	0	0
Rhinitis, catarrhal.....	2	0	4	2
Rhinitis, chr. degen.....	9	0	5	4
Rhinitis, allergic.....	2	0	2	0
Sinusitis, chr.....	18	0	16	2
Mastoiditis.....	4	0	4	0
Otitis media, chr.....	7	5	0	2
Otitis externa.....	18	16	1	1
	138	93	34	11

## UROLOGY SECTION

*Cystostomy Wounds.* Four patients with wide suprapubic wounds have been seen

and in these cases chlorophyll instillations have cleaned up the bladder mucosa, have made the urine clear and have aided in healing of the surface wound. In one case, osteomyelitic, exposed pubic bones have been promptly covered by granulation tissue. One of these patients subsequently developed a very severe calculus pyelonephritis, and ureteral catheterization to relieve the obstruction revealed a very thick purulent and bloody urine with fibrin

*Cystitis.* One case of intramural cystitis was treated by instillation of chlorophyll into the bladder every other day for a couple of weeks. There was no improvement in the pain, tenesmus, frequency and urgency.

*Nonspecific Urethritis.* In three cases which varied in duration from six months to seventeen months, a non-specific urethritis which was resistant to sulfathiazole and penicillin was treated by daily ure-

## UROLOGY SECTION

Diagnosis	No. of Cases	Cured	Benefited	Not Benefited	Method of Rx and Comment
Cystostomy.....	4	0	4	0	Wet dressing and irrigation
Nephrostomy.....	2	0	2	0	Irrigation
Cystitis.....	1	0	0	1	Instillation
Non-specific urethritis.....	3	0	0	3	Instillation
	10	0	6	4	

clots which repeatedly plugged the catheter. The ureteral catheter was irrigated by injection of 2cc. of chlorophyll solution hourly all night, and by morning the urine was clear, the catheter was draining well and the temperature had dropped from 104°F. to near normal, where it remained. Subsequently the ureteral catheter had drained freely and the urine has been kept clear by less frequent irrigations with chlorophyll.

*Nephrostomy.* Two such patients have been treated by chlorophyll irrigations. In one, calculus pyonephrosis with jaundice and uremia made emergency nephrostomy necessary. In this very sick patient, the urine was so purulent as to clog the drainage tube. Tidal irrigation with chlorophyll solution gave a clear urine after forty-eight hours and the patient made a rapid recovery. In the other case, pelvithotomy was followed some months later by reformation of stones, a perinephric abscess and purulent drainage through the old incision. Irrigation of this cavity with chlorophyll solution caused the suppuration to cease, the cavity to obliterate and the tract to close.

thral instillations with chlorophyll solution. These cases were treated for fourteen days without benefit and with no ill effects.

## CONCLUSIONS

1. Officers on the various selections of the Surgical Service were asked to submit in writing their observations on the use of chlorophyll in the cases here reported. These observations were compiled and consolidated into the following group opinions:

a. When using chlorophyll for infected wounds, the officers were impressed by the rapid disappearance of objectionable odors and by the remarkable cleanliness of the wound within two or three days.

b. Granulation tissue seemed to be of finer texture, more firm and to form more rapidly with chlorophyll than with other agents previously used.

c. Epithelization also appeared to be stimulated more by chlorophyll than by other agents such as penicillin.

d. No skin irritation or adverse systemic reactions have been noted and many patients have spontaneously commented that the chlorophyll wet dressing has been

much more comfortable than similar dressings with saline solution, boric solution or penicillin.

e. If chlorophyll is used as a wet dressing over a period of a week or more, there is a tendency to overproduction of granulation tissue so that after the wound is clean and odorless it is advocated that chlorophyll ointment gauze be used instead of the wet dressing.

f. It was noted in all suppurating cases that chlorophyll caused cessation of pus formation in two or three days; and thenceforth, there was only a slight serous discharge. This includes the osteomyelitis and thoracic empyema cases which are noted for prolonged suppuration by other modes of treatment.

g. In the nose and sinus cases, the officers, some of whom used chlorophyll themselves, noted that chlorophyll gave more rapid changes in the nasal mucosa and had a quicker effect in stopping purulent drainage than other agents formerly used. All these patients have noted a freer breathing after chlorophyll instillation without the disagreeable after-effects of ephedrine.

h. All officers and patients have noted the bland qualities of chlorophyll and the ease of tolerance by the patient even when instilled into the eye, the nose, deep intra-abdominal abscess cavities and the pleural cavity.

2. A general report is presented, covering the use of chlorophyll over a nine-month period in over 400 clinical cases, representing a wide variety of surgical conditions.

3. Basic biological data are presented from the literature and from personal research to attempt to establish a firm and rational basis for the use of chlorophyll in clinical cases.

4. It is to be emphasized that chlorophyll is not antibacterial and is but weakly bacteriostatic so that its beneficial effect is exerted through stimulation of the cells of the host. That this agent is efficacious is evidenced by the fact that this

hospital uses one-half to one-third the amount of penicillin used by other army hospitals treating similar cases.

5. Finally, it is believed by the author that the water-soluble chlorophyll preparations herein described have a broad military application and that wide use is highly desirable. The author does not present chlorophyll as a cure-all but "is convinced that chlorophyll is the best agent now known for use in the treatment of suppurative diseases, indolent ulcers or wherever stimulation of tissue repair is desired and local application of this drug is possible."

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THE prognosis of gas-bacillus infection depends upon the patient's resistance, the part of the body involved, the virulence of the organism, and the treatment. The extent of operative treatment depends upon the severity of the individual case.

From "Fractures and Dislocations for Practitioners" by Edwin O. Geckeler (The Williams & Wilkins Company).

# SURGICAL OBJECTIVES OF ANORECTAL REPAIR

## ANATOMIC FACTORS IN PATHOLYSIS AND DRAINAGE OF ANAL INFECTIONS

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**T**HAT free surgical drainage of anal infections can be established without endangering the muscular structure of the anorectum is proved by recent anatomic studies which show: (1) that instead of being arranged in a series of rings, as has long been supposed, the sphincteric musculature exists in the form of a web which provides definite guiding landmarks; (2) that infection from the anal glands gains access to the meshes of this web so as to complete a mechanism of patholysis for the clinical entities, commonly termed fistula, abscess, ulcer, etc.; (3) that the surgical landmarks afforded by this muscular web show the surgeon where, how deep, and where not to make his incisions to establish drainage. Thus, with the guidance of landmarks and knowledge of the patholytic mechanism afforded by the new concept of surgical anatomy, the surgeon is no longer handicapped by the restraints inherent in the former concept which regarded the sphincter as being composed of a mere series of muscular rings.

Although the surgeon has long been aware of the extraordinary need for drainage that exists in rectal surgery, he felt unable to establish these drainage procedures because of the fear of creating structural damage. While he recognized that the anorectum is an infected field, and that the nature of anal infection is such that surgical drainage is imperative, he was discouraged by the supposed vulnerability of the sphincteric musculature. Moreover, because the constricting action of the sphincter hinders or blocks drainage he realized that the need for adequate surgical procedure is all the more

emphatic. And yet, in spite of these important needs for free drainage, the hand of the surgeon has always been restrained by the apprehension of causing injury to the tissues.

This worry developed because the anorectal musculature was regarded as having a ring-like arrangement. All investigators from the time of Galen, in the second century, until the time of Holl, in the nineteenth century, emphasized a ring-like arrangement of the anorectal musculature. Consequently, any freedom of surgical maneuvers to establish drainage was unthinkable because it seemed that injury to the "ring structure" would be inevitable. Thus, arose a dilemma for the rectal surgeon—extraordinary need for drainage in a structure of great vulnerability.

The restriction imposed by this false concept of the anorectal structure brought forth many unsurgical attempts at compromise which were eventually sanctioned by the passage of time. Because free surgical drainage was necessary and because it was contraindicated by the supposed ring arrangement, a number of technical procedures were used which not only failed to relieve the original pathological condition but often caused complications.

For example, a spastic or stenosed sphincter that cried for rest, relaxation and drainage by free incision was either treated by strenuous methods of divulsion, or, by a "medical" incision which did not relieve. In fistula, although the vast majority arose from an abscessed row of crypts, emphasis was placed upon a single "internal opening," and the line of crypts was ignored. John Arderne said five

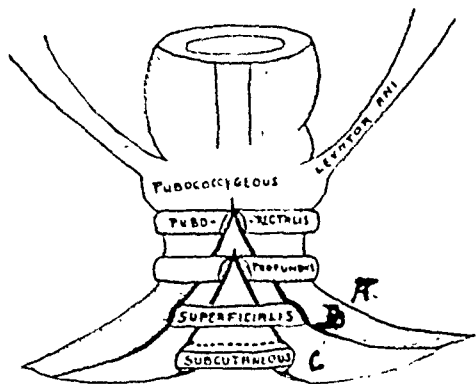


FIG. 1. Structural scheme of anorectal musculature. The inverted v-shaped sections show how sheaths of conjoined longitudinal muscle divide the external sphincter into its components and, thus, form a web. A, B and C, outer, middle, and inner sheaths, respectively.

hundred years ago: "Fistulous tracts must be opened from their source to their termination regardless how much muscle intervenes." However, the surgeon did not realize that the sphincter is composed of five divisions and that the lower-most of these can be divided in a certain area without endangering continence. Consequently, such tracts were incised in stages and sometimes the "Seton method" was used. Not realizing that on infralevator abscess can be cured usually by excising the necrotic anal lining at the same time that the abscess is evacuated, the unrecognized patholytic mechanism made drainage of the abscess the sole objective.

Another handicap for the surgeon who lacked guiding landmarks was the disregard of the need for orificial technic. This was shown in the surgery of prolapsed hemorrhoids. Instead of applying a surgical procedure within the canal so that the diseased tissue could be excised completely at the proper level which would prevent the subsequent deformity often attributed to the mis-called Whitehead operation, the surgeon was forced to resort to still another compromise: He excised only part of the diseased tissue.

Compromise efforts in the endeavor to obtain adequate surgical drainage of the anal infections are no longer needed. The discovery of the web-like arrangement of the anorectal musculature not only removes the need for compromise, but provides the surgeon with a workable concept whereby he can apply his technical procedures with precision and without danger to anatomic structures. The "mechanism" of the anal infections has been clarified as the result of the understanding of the arrangement of the anorectal musculature and the part which is played by the anal glands in relationship to this musculature. Not only is the mechanism of patholysis explained, but the surgeon is provided with structural landmarks which guide his technical procedures so that free and safe drainage may be instituted.

What is meant by the web-like arrangement of the anorectal musculature? What is the anatomic mechanism that causes the anal infections to manifest themselves in the clinical entities known as ulcer, fistula, abscess, etc.? What are the guiding surgical landmarks of this new anatomic concept, and how can these be used to correct inflammatory distortions and destroy the patholytic mechanism?

Although many factors showing the web-like arrangement of the sphincter are set forth in other spaces, we emphasize here the two anatomic findings that make the sphincter arrangement a "web" instead of a "ring-series" as has long been supposed: The first is simply that the levator components interweave with the sphincter components to form a web. Instead of being a muscular diaphragm separate from the sphincter ani, the levator ani has components which enter into firm union with the sphincter. These levator components, in passing from their origin on the posterior surface of the symphysis pubis to their insertion on the anterior surface of the sacrum, coccyx and median raphe, not only envelope the anal canal, but they interweave with the divisions of the external sphincter. That

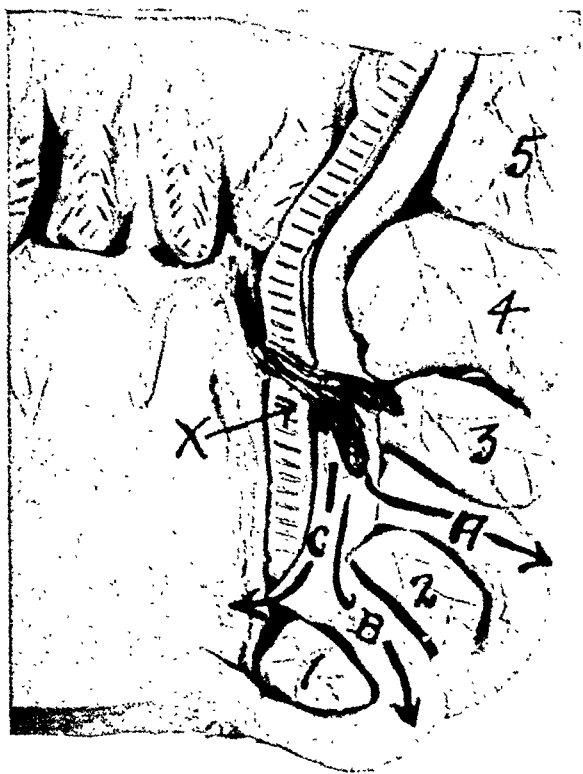


FIG. 2. Schematic model of section through anorectal wall indicates paths for extension of infection from branched tubular anal glands (x). 1, 2, 3, 4 and 5, sphincters subcutaneous, superficialis, profundus, puborectalis, pubococcygeus, respectively. A, B and C, outer, middle and inner sheaths, respectively. Infection passing from glands along path c leads to ulcer; along b, to intrasphincteric fistula; along A, to infralevator abscess and extrasphincteric fistula.

these components from the levator and sphincter sources intermingle and yet retain individuality, is proved by the nerve supply. Some receive the levator innervation from the fourth sacral; others receive the sphincteric innervation from the inferior hemorrhoidal branch of the internal pudendal nerve. (Fig. 1.)

The second anatomic factor showing the web-like arrangement of the anorectal musculature is the conjoined longitudinal muscle. This anatomical element contributes strong reinforcement for the pelvic diaphragm and explains the rarity of herniation through that structure. It is "conjoined" because it receives components from the external longitudinal coat, the levator ani, anterior and posterior longitudinal bands, and elements of contiguous mesothelial origin. In the form of fibro-



FIG. 3. Prolapsed hemorrhoids. Note line of anal crypts which has descended externally. The "dentate level" (see text), determines line of excision. Note degree of surgical exposure afforded by the Eaton anal speculum.

muscular sheaths it passes downward along the anorectum, interweaving with the sphincter components, binding them together and giving further support to the web-like arrangement.

The anal glands complete the patholytic mechanism. The etiologic rôle of the branched tubular glands lying in the base of the anal crypts long has been realized. It has been emphasized that their penetration of the anal wall constitutes a means of conveying infection to the intramural tissue. With the recognition of the web-like arrangement of the anorectal musculature we see that such penetration is instrumental in the dissemination of infection. When the infection from these penetrating glands is received into the meshes of the web, the patholytic process is guided by the meshes to form the various clinical entities. Accordingly, a superficial penetration will be confined to the innermost muscular spaces and give rise to a typical clinical picture. The involvement of this space will produce cellulitis, ulcer, stenosis, etc. A deeper penetration of the glands will result



FIG. 4. Longitudinal section of anal wall (low power). Note anal crypt (X) with branched tubular gland (see Fig. 5.) in its base.



FIG. 5. Branched tubular gland in base of anal crypt (see Fig. 4.). Note inflammatory reaction (high power).

in an infectious process which will be guided by the limiting sheath of the conjoined longitudinal muscle so that it follows the path of least resistance between the sphincters to cause a intrasphincteric fistula. A still further penetration of the wall may involve the infralevator space with the development of "ischio-rectal" abscess. (Fig. 2.)

Aside from explaining the mechanism of the clinical entities, and from providing the surgeon with a clear concept of the true surgical anatomy, and aside from dispelling the illusions which arose from the false and misleading "ring concept," another practical advantage is that this web arrangement shows true guiding landmarks which enable the surgeon to correct inflammatory distortions precisely and safely. By inspection and digital palpation of the anal canal, he can recognize critical lines and levels that are produced by the muscular web structure. By understanding the arrangement of the anorectal musculature, these landmarks can be interpreted in terms of the underlying structure.

The recognition and use of these surgical

landmarks are necessary to attain the surgical objectives of every anorectal repair, which are: (1) The complete removal of the pathologic tissue; (2) the destruction of patholytic mechanism; (3) the provision of rest and relaxation of a spastic or stenosed anal canal, and (4) the assurance of adequate surgical drainage.

These guiding landmarks show the surgeon the proper level within the anal canal at which to excise a prolapsing hemorrhoidal membrane where the line of crypts has descended through the anal opening. Doubt in regard to this level brought misunderstanding regarding the amputative type of operation, led the surgeon to believe that stricture and eversion were inherent to it and forced him to adopt the compromise method of excising only part of the diseased tissue. The anatomic level of such excision is the "dentate level" which is found at the mid-point between the puborectalis and the internal muscular groove. This level represents the embryonic junction between hindgut and proctodeum. This is the site to establish a "surgical dentate line," in reference to which, one famous proctologist said: "Because that is

where God put it, that is where the surgeon must keep it."

Rest and relaxation of a spastic or stenosed anal canal—a condition which is present in some degree in all the anal infections—can be relieved by deep incision in the posterior mid-line. Guidance for such an incision is shown by the surgical landmarks. At the margin of the anal canal, the external intermuscular groove is felt, and overlying it is the subcutaneous division of the external sphincter. Separating this muscle from the termination of the internal sphincter is the internal intermuscular groove, the so-called "white line of Hilton," caused by the insertion of the innermost sheath of the conjoined longitudinal muscle. Finally, the puborectalis muscle is felt as a rounded muscular ledge separating the anal canal from the ampulla of the rectum. This structure is not only the last guardian of continence, but serves as a sling or splint when incisions for drainage, for relaxation and for removal of fistulous tracts are made in the more caudad musculature.

The fact that the puborectalis muscle and the profundus division of the external sphincter are "extrinsic muscles"—a term which signifies that they are not enveloped by sheaths of the conjoined longitudinal muscle—has important significance in the surgery of fistula. These muscular divisions are the real guardians of continence because fistulous tracts are guided through the more caudad, "intrinsic," sphincteric divisions by the sheaths of the conjoined longitudinal muscle. This important anatomic fact constitutes an explanation for many proctologic pronouncements which always have seemed arbitrarily dogmatic. It explains why John Arderne was correct in his assumption regarding fistula (v.s.). It explains why modern proctologists who have had the greatest experience state that they excise the fistulous tracts and care not what structures are involved. They contend that incontinence is due to incomplete excision of diseased tissue, packing of fistulous wounds, inadequate drainage and inade-

quate after-care and not to the incision itself.

#### COMMENTS

Because preservation of surgical landmarks is necessary for surgical guidance, all advantages must be taken to secure a degree of exposure which is adequate, and yet, does not traumatize. To gain this exposure, certain accessory aids are important, e.g., caudal transsacral anesthesia, the prone, semi-inverted position of the patient on the table and special instruments to facilitate a technic of orificial surgery.

#### SUMMARY

A few practical surgical inferences arising from the modern concept of the surgical anatomy of the anorectum are suggested.

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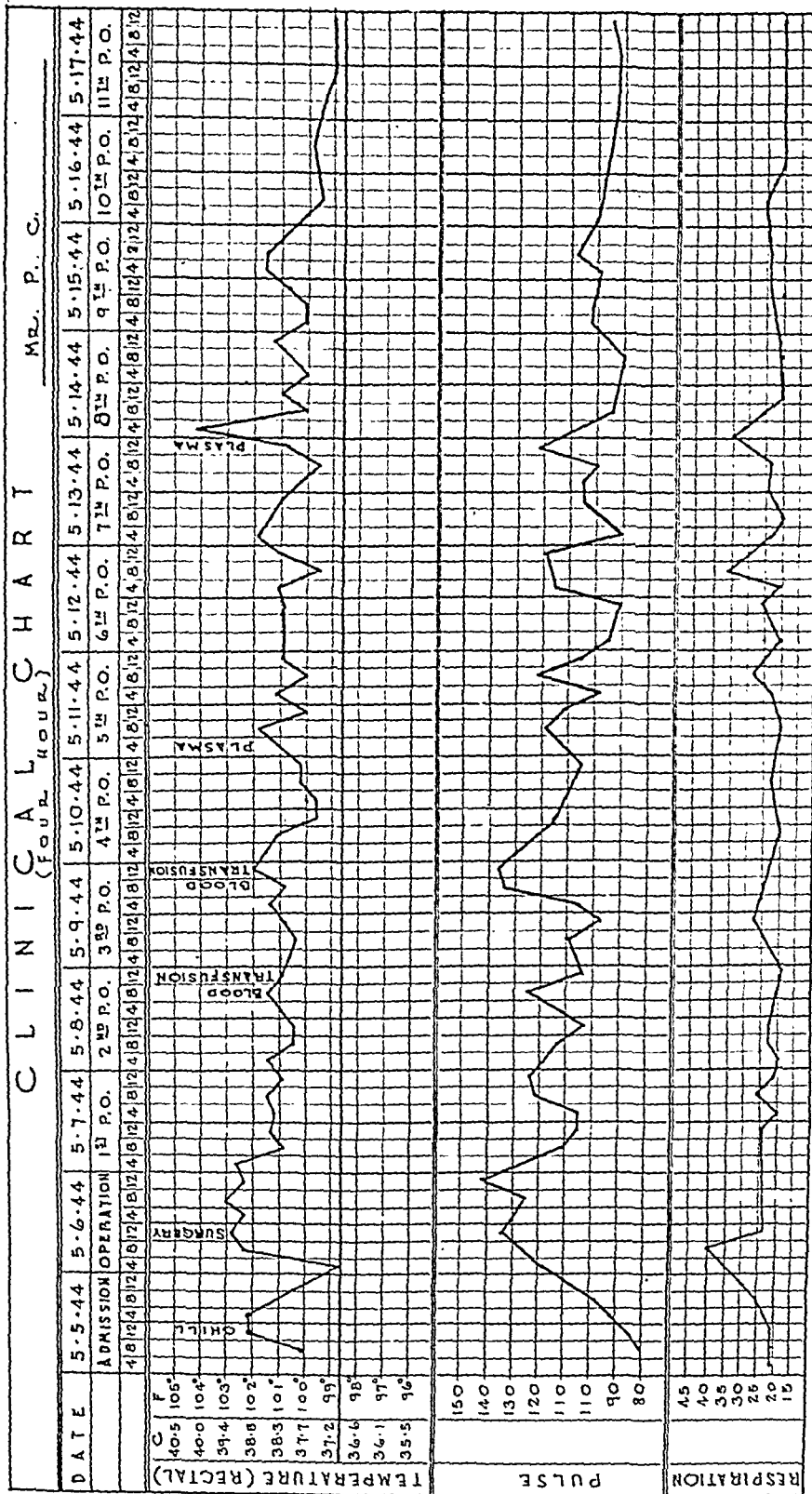


FIG. 1.

days. The following case is presented in detail to illustrate the method of treatment:

#### CASE REPORT

A white male, twenty-two years of age, came to the hospital complaining of lower abdominal pain for twenty-four hours previous to admission. The pain became generalized on the day of admission and was accompanied by vomiting. He had vomited fifteen times. On arriving on the ward he developed a chill which lasted fifteen to twenty minutes. His bowels moved normally before the onset of the illness and had moved once the day before admission. The patient admitted that he had received an immunization "hypo" and a vaccination the day before coming to the hospital. He had taken no cathartics.

Physical examination on admission showed a well nourished, white male with a temperature of 102.6°F. Pulse rate was about 90 per minute. The nasal mucosa was reddened. The tongue was slightly dry and coated while the pharynx was mildly injected. The abdomen showed tenderness equally in the right lower quadrant and left lower quadrant but was soft throughout. There appeared to be some variable voluntary rigidity. Peristaltic sounds were somewhat diminished. The right arm showed a moderate area of erythema and induration at the site of the immunization "hypo" and a vaccination scratch mark on the left arm. There were no demonstrable rectal findings by digital examination.

The original impression was an immunization reaction. Observation for twenty-four hours after admission showed a progressive process in the abdomen. Temperature remained about the same as on admission while distention of the abdomen began. Generalized rigidity, involuntary type, developed together with generalized tenderness. Severe rebound tenderness was now present. The vaccination reaction had subsided. At this time the presence of appendicitis seemed more evident and an operation was performed.

The abdomen was opened through a McBurney incision. The appendix which was adherent to surrounding loops of small bowel was delivered through the incision and removed. The appendix measured 9 cm. in length by 1½ cm. in diameter at its thickest portion. It was indurated, friable and covered with exudate. An

8 mm. perforation was present 1 cm. from the base. The meso-appendix was friable and indurated. The peritoneal cavity contained a profuse amount of greenish purulent fluid with little or no odor but unfortunately smears and cultures were omitted. Fifteen Gm. of sulfanilamide crystals and 50,000 units of penicillin were placed in the peritoneal cavity and the wound was closed without drainage.

Postoperatively the patient was placed in a semi-Fowler's position with a Levine tube in place for continuous gastroduodenal suction. Close daily observations were made of the urine and blood, and a fluid balance was maintained by an intravenous intake of 3,500 to 4,500 cc. of fluids. Penicillin was continued intramuscularly in doses of 25,000 units every three hours while the sulfonamide blood level was maintained between 3 and 8 mg. per 100 cc. by intravenous sodium sulfadiazine.

On the second postoperative day a few peristaltic sounds were noted but abdominal distention in moderate degree still persisted. The patient stated that he passed flatus on the third postoperative day. This appeared to be true since the abdominal distention was reduced and peristaltic sounds were definitely increased. The temperature had decreased from a preoperative temperature of 102.6°F. to 101.4°F. rectally with a general improvement of condition by the third postoperative day. The fourth day after surgery, the patient complained of pain in the left mid-axillary line of the lower chest. Auscultation revealed a friction rub. Roentgenologic study of chest at this time showed the diaphragm to be elevated on either side with some haziness of both lung bases. These chest complications did not progress to a pneumonic process but were nearly cleared by the tenth postoperative day. The sutures were removed from the wound on the ninth postoperative day with primary healing and by this time recovery seemed positively assured. Sodium sulfadiazine was discontinued on the tenth postoperative day and penicillin on the twelfth day. The patient was allowed out of bed on the seventeenth postoperative day. Convalescence from this time on was rapid until the patient was discharged.

Throughout the postoperative course, repeated rectal examinations were done but there was never evidence of a pelvic abscess or mechanical obstruction of the bowel. During



this time, the blood proteins were replenished by the administration of whole blood and plasma.

Table I shows a summary of laboratory studies performed during the crucial period of convalescence.

expected to reduce the production of penicillinase by the colon bacillus. Then if sufficient penicillin is used locally in high concentrations as suggested by Altemeier, any excess beyond that required in

TABLE I  
SUMMARY OF LABORATORY STUDIES

Date	RBC Count	WBC Count	Per Cent Polys.	Urin-analysis	Blood Sulfa (Free) Level	Total Blood Protein	Serum Alb.	Serum Glob.	Remarks
5/5/44	5,180	21,550	90	Neg.	...	...	....	...	Adm.
5/6/44	.....	12,400	86	Neg.	...	...	....	...	Op.
5/7/44	4,640	8,400	74	Neg.	5.3	...	....	...	1st P. O. day
					8.2				
5/8/44	5,140	8,500	63	Sugar 3 plus	6.9	...	....	...	300 cc whole blood
5/9/44	4,920	6,050	60	Neg.	3.9	...	....	...	3rd P. O. day
5/10/44	4,790	9,350	73	Neg.	...	...	....	...	300 cc whole blood
5/11/44	5,190	11,950	80	Sugar 2 plus	4.1	...	....	...	5th P. O. day
5/12/44	5,090	13,900	72	Sugar 2 plus	3.4	...	....	...	6th P. O. day
5/13/44	4,630	14,250	82	Sugar 1 plus	3.6	...	....	...	500 cc plasma
5/14/44	5,090	8,700	62	Neg.	1.5	...	....	...	500 cc plasma
5/15/44	4,850	9,400	71	Neg.	1.9	5.4	2.84	2.5	9th P. O. day
5/16/44	5,170	10,950	65	Neg.	2.1	...	....	...	10th P. O. day
5/23/44	.....	.....	..	.....	...	5.3	3.7	3.1	17th P. O. day

The postoperative therapy in summary consisted of adequate fluid intake, continuous gastroduodenal drainage, narcotics, blood and plasma for replenishment of serum proteins, and postoperative exercises graduated as tolerated. Added to these commonly accepted procedures a total of 45 Gm. of sodium sulfadiazine was given intravenously and reinforced by the total administration of 2,300,000 units of penicillin intramuscularly.

Graphic records Nos. 1 and 2 shows the general improvement of the patient as therapy continued. These records are self-explanatory.

#### COMMENT

When one digests the literature on the subject of penicillinase, the use of penicillin in treating *Bacillus coli* infection seems hopeless. However, since sulfonamides produce bacteriostasis in peritoneal mixed infection, their use can be

the neutralization of penicillinase may be bacteriostatic to the organisms of the mixed infection of peritonitis of appendiceal origin.

#### CONCLUSIONS

1. The definite increased rate of recovery and decreased secondary complications of appendiceal peritonitis, justifies the combined use of sulfonamides and penicillin therapy.

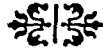
2. Penicillinase is not as completely inhibitive of penicillin as the first experimental work would indicate.

3. A detailed case report illustrates the method of treatment.

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IN early cases of peritonitis, if the focus of infection be removed the abdomen often can be safely closed without drainage. The capability of the peritoneum to overcome a certain amount of infection is truly remarkable.

From "A Short Practice of Surgery" by Hamilton Bailey and R. J. McNeill Love (H. K. Lewis & Co. Ltd.).

# LARYNGEAL COMPLICATIONS AFTER THYROID OPERATION\*

## SYMPTOMS, PROGNOSIS AND TREATMENT

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ALTHOUGH thyroid operations are performed by general surgeons, their complications are seen by the laryngologist. Most of these complications are due to damage to the nerves which occurs during the operation, and cause anxious moments for the operator who does not have a clear conception of what changes take place in the larynx. My aim is to clarify this picture and show the changes that will be encountered if one or more laryngeal nerve is affected. The symptoms following these injuries are manifold, but they can be divided into two main groups: first, changes in the voice; second, changes in the breathing. There are other symptoms such as spasmodic cough, difficulty in deglutition, and inability to clear the larynx of mucus. To be able to explain what takes place, it is necessary to discuss the normal innervation of the larynx and its physiology. (Figs. 1 and 2.)

Some controversy still exists over the relationship of the laryngeal nerve to the thyroid gland, and also over the innervation of the larynx itself. It is known that the larynx is supplied by two nerve trunks which originate in the vagus: (1) the laryngeal inferior, or recurrent nerve which supplies all the laryngeal muscles with motor fibers except the cricothyroid muscle; (2) the laryngeal superior nerve which carries sensory fibers in the strong external portion to the larynx, and motor fibers in the weaker internal portion to the cricothyroid.

The schematic picture (Fig. 3), the work of Professor Onodi, who did the pioneer

work on the nerve supply of the larynx, is still accepted by most laryngologists.

It is evident from Onodi's picture that besides the two main nerve trunks, the lowest branch of the laryngeal superior nerve is connected with the medial branch of the inferior nerve under the mucosa which covers the crico-arytenoid posterior muscle, forming the so-called ansa Galeni. Both nerves have connections with the sympathetic nerves. Besides these clear cut cases there are many irregularities of innervation or overlapping innervation. The recurrent nerve may send some motor fibers to the abductors, adductors and tensors. The complexity of this innervation is evident from the different, and by no means clearly explainable, laryngeal conditions which are found when these cases are followed up, and which cannot be interpreted as injury to only one specific nerve.

The most important structure which is frequently affected by the nerve injuries is the crico-arytenoideus posterior, also called the posticus or abductor muscle, innervated by the laryngeal inferior or recurrent nerve. Second in importance is the interarytenoid muscle. While the innervation of the abductor is clear cut, there is considerable difference of opinion regarding the nerve supply of the interarytenoid muscle. Heyd,<sup>1</sup> quoting Frazier,<sup>2</sup> states that the interarytenoid muscle is supplied by the internal branch of the superior laryngeal nerve, while Ziegelman<sup>3</sup> claims that a combination of recurrent and superior nerves is

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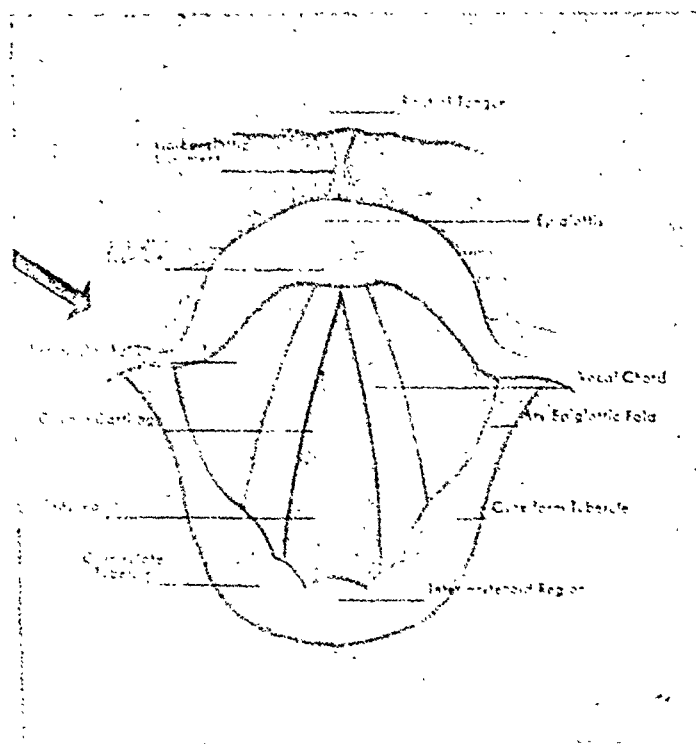


FIG. 1. Normal larynx in respiration.

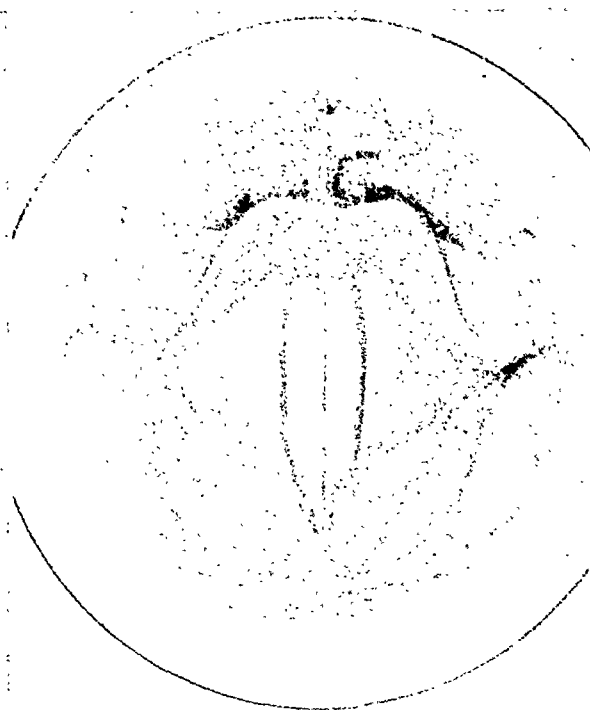


FIG. 2. Normal larynx in phonation.

responsible for the innervation of the muscle. Lemere,<sup>4</sup> who did probably the best work in recent years in investigating all of these fields, is of the opinion that the superior nerve runs only through the muscle and supplies the mucosa only with sensory fibers. In this respect he is in full agreement with Onodi. Grossman<sup>5</sup> goes so far as to claim that the nerve which goes through the muscle does not have any motor fibers at all. Jackson<sup>6</sup> and the majority of laryngologists are of the opinion that the interarytenoid muscle is supplied by the anastomosis of both recurrent nerves.

The third muscle which is affected is the cricothyroid, which is supplied by the superior laryngeal nerve; and its rôle in postoperative complications is much more important than is acknowledged by most surgeons, who, while trying to avoid the laryngeal inferior, may injure the superior when removing the thyroid gland. This muscle, which tenses and relaxes the vocal cords, determines the ultimate position which these cords will assume when fixed, and, as a powerful adductor, is responsible for maintaining a median or paramedian

position in case of complete recurrent paralysis.

The location of the laryngeal inferior nerve is by no means the same in every case. Lahey<sup>7</sup> claims the most probable site is between the horn of the thyroid cartilage and the point where the nerve passes under or over the inferior thyroid artery, where, during attempts to control the bleeding, the nerve may become caught. He advocates the exposure of the nerve routinely while performing the thyroidectomy, and claims having performed 10,000 thyroidectomies without injuring the recurrent nerve. Ziegelman<sup>8</sup> also found that the relationship between the inferior thyroid artery and the recurrent nerve is quite variable. This observation increases confidence in Lahey's method of operation. On the other hand there is another school of thought which tries to avoid the recurrent nerve as much as possible.

As for the laryngeal superior nerve, the external branch is in close relationship with the superior thyroid artery. The injury of this nerve causes spasmodic cough, inability to evacuate mucus, and disturbance of deglutition. It is easily injured during

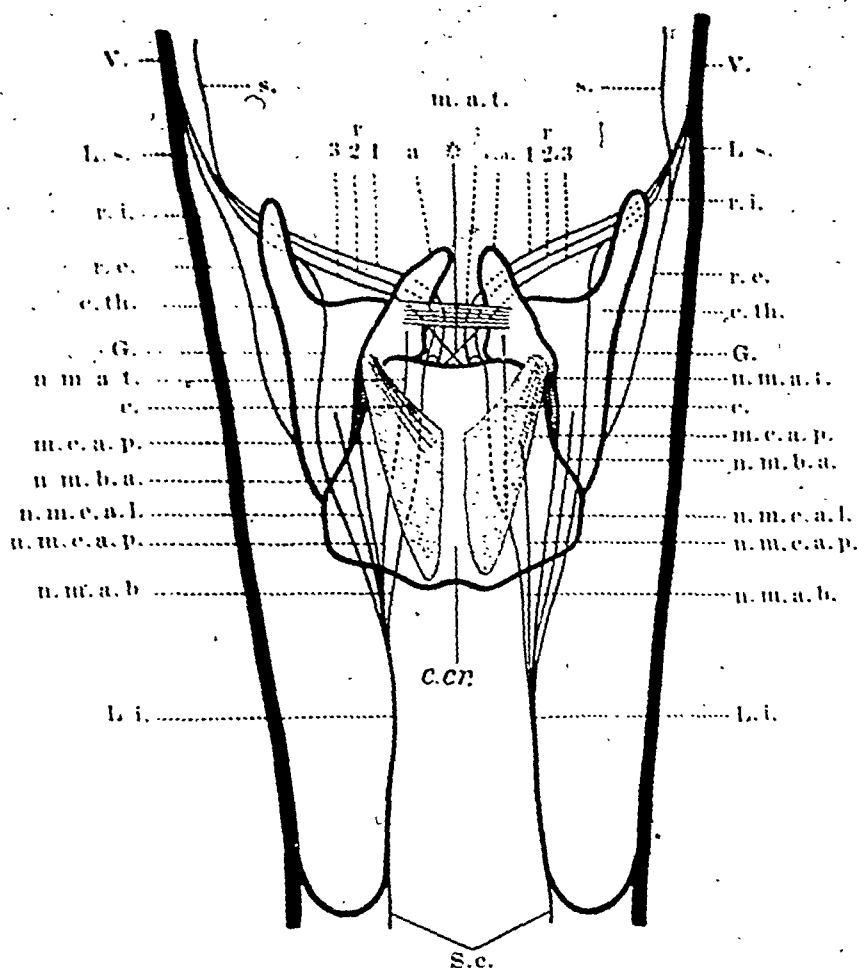


FIG. 3. Topographic anatomy of the motory and sensory fibers of the normal larynx (after Onodi).

the ligation of the vessels unless caution is used. Frazier,<sup>8</sup> discussing Ziegelman's paper, warns that a careful ligation of the upper pole of the enlarged thyroid is important here, where not only the external but the internal branch of the laryngeal superior nerve may be injured. He advocates dissection of the upper pole, isolating the arteries and the veins one by one and ligating them separately. With this method he claims much less postoperative discomfort.

All these methods will be satisfactory in many instances, but it is possible that scarcely a surgeon with any experience can claim a complete absence of laryngeal complications.

There are about 10 per cent of the thy-

roid cases in which paralysis of one vocal cord exists preoperatively without the patient or the surgeon being aware of it. Therefore, it is of utmost importance that every patient, before a thyroid operation is performed, should have a routine laryngeal examination by an expert laryngologist, who will be able to warn the surgeon in advance to be doubly careful of damaging the other nerve. In such cases a malignant growth, which involves the nerve quite early, should be suspected.

Not all of the cases which show a clinical picture of paralysis of the vocal cords are due to complete severance of the nerve. The recurrent nerve is extremely sensitive to pressure and to traction which may cause temporary impairment of the nerve. While

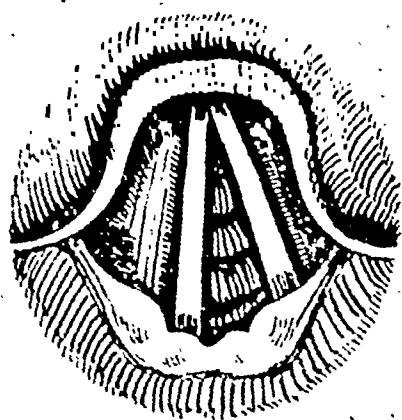


FIG. 4.

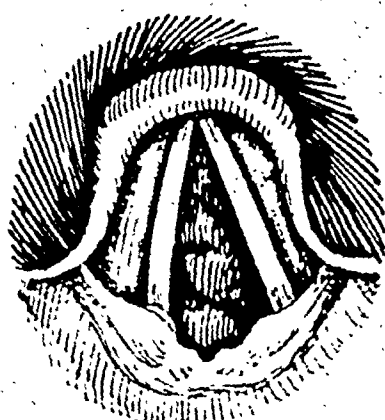


FIG. 5A.

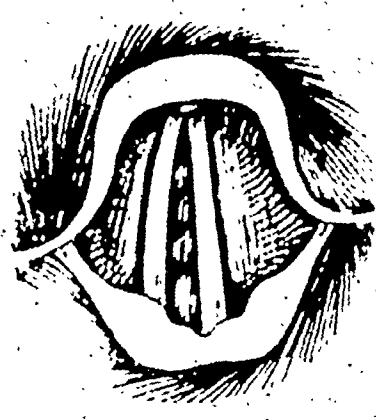


FIG. 5B.

FIG. 4. Paralysis of the abductor on one side. The paralyzed vocal cord (R) is in the mid-line. Breathing is perfect, the voice most of the time good, except for some hollowness which can be noticed only by experts. The patient may experience some fatigue after too much talking.

FIG. 5. Total recurrent paralysis on one side. The paralyzed cord is in abduction (cadaver) position. The voice is impaired, hoarse, but if the normal vocal cord goes over the mid-line the voice may improve. The breathing is good. There may be some difficulty in expectorating mucose.

Lahey and many other goiter surgeons claim that plain traction does not damage the nerve. Heyd observed inspiratory stridor as a result of traction of either the superior or the inferior poles of the thyroid. He is convinced that traction is a dangerous procedure, especially if the mobilization is carried out from below upwards, particularly in substernal goiters. The extreme sensitivity to pressure due to clamps, hematoma, adhesions or malignant growths gives rise to a theory that the motoric fibers which supply the abductors are in the external layer of the nerve, thus more liable to damage. Lemere denies this supposition. How much pressure the nerve will stand as a primary insult without suffering permanent impairment is still not known to us, for the pressure causes damage after which a progressive degeneration of the neurons produces permanent paralysis.

King<sup>9</sup> observed a case in which, twelve years after a thyroid operation, an autopsy was performed and paralysis of both vocal cords was found without the severance of either of the nerves. One nerve had a neuroma, while in the other there were only degenerative changes at the site of the pressure. Experience has shown that treatment of some of these cases and early electric stimulation may restore the func-

tion of a damaged but not severed nerve, while later not only degenerative changes in the nerve but also atrophic degeneration in the muscles and stiffening of the joints have to be dealt with.

Figures 4, 5 and 6 show conditions in the order of the frequency with which they occur in connection with the impairment of the nerve supply. (Figs. 4, 5, 6 and 7.)

Besides these common conditions there have come under my observation during the last two years odd and not easily explainable cases, including over 150 cases of unilateral paralysis and over thirty cases of bilateral paralysis of the vocal cords. In following up these cases, I noticed that while some conditions remained the same, changes occurred in several instances; and while, in most instances of complete paralysis, the vocal cord definitely took a mid-line position, as New<sup>10</sup> claims, I noticed more than once a change from middle to intermediary (cadaver) position or vice versa, but I never observed any further changes after a cord moved from primary to secondary position.

The clinical symptoms manifested include changes of the voice varying from slight to complete hoarseness, as well as occasional spasmodic coughing spells, retention of mucus due to the inability to

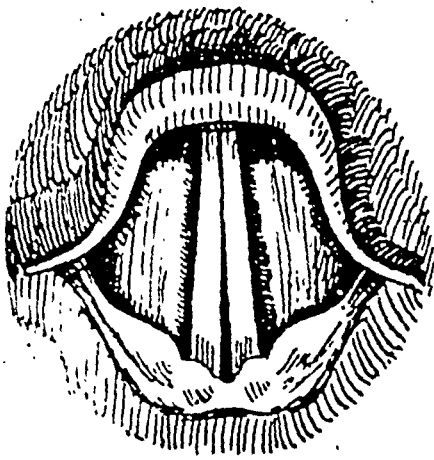


FIG. 6. Paralysis of both abductors. Both cords are fixed in mid-line. Breathing difficulties range from stridor and inspiratory dyspnea to complete suffocation. The patient sleeps noisily; the voice may be perfect but the patient gets tired due to anoxemia from the least physical exertion. If the opening between the two cords is less than 2 mm., tracheotomy is advised. This is the most dangerous condition of all; but because the voice is good little attention is paid to it, while more notice is paid to the poor voice that indicates no danger.

clear the throat, difficulties with the breathing ranging from inspiratory stridor and loud snoring to severe dyspnea even in times of rest. The loss of voice, while it is annoying, is not a serious complication. Most of the patients with unilateral paralysis of the vocal cord ultimately improve because of the compensatory power of the other cord. In some patients the voice remains hoarse because the paralyzed cord assumes an extreme abduct position. If both cords are paralyzed and if the patient's voice is hoarse, the condition is not serious; but if the voice is improving and at the same time the difficulties with breathing increase, the surgeon should be on the alert.

While most authors observe about twice as many cases of paralysis on the left side as on the right, no such large differences were noticeable in my series of cases. There were about six times as many women as men with vocal cord involvements accord-

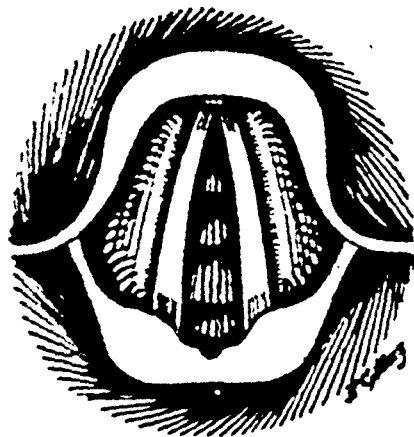


FIG. 7. Complete paralysis of both recurrent nerves. Both cords are in abduction (cadaver) position. The breathing is good, but the voice is poor, ranging from hoarseness to complete aphonia. Expectoration is also difficult.

ing to Means.<sup>11</sup> This is probably due to the fact that thyroid disease is more prevalent among women.

As far as operative therapy is concerned, I resort to tracheotomy as a palliative treatment in instances in which both cords are paralyzed in the mid-line and if the patient shows difficulty in breathing. Of the operative procedures I shall mention those developed in recent years:

1. Jackson,<sup>12</sup> in his book, advocates evisceration of the larynx and ventriculocordectomy, which has never become popular because the excessive tissue formation and scars have a poor effect on the voice.

2. An apparently ideal procedure is the restoration of the nerve by surgery, which has been tried by Frazier,<sup>13</sup> Ballance,<sup>14</sup> and Lahey,<sup>7</sup> but the results are not good enough to be adopted by surgeons as a whole.

3. Displacement of the cord through laryngofissure and similar methods defeats the purpose of operation for restoration.

4. An ingenious operation was devised by B. T. King<sup>15</sup> in 1939. He transfixed the omohyoid muscle to the arytenoid cartilage and thus expected to establish the necessary movements of the paralyzed cords. While this procedure is feasible and has been successful in some of his cases, in his

second report of more than thirty cases in 1941, he said that he no longer transfixes the muscle, but partially separates the arytenoid cartilage, and transfixes it to the thyroid cartilage, thus achieving a better result and making the operation less complicated.

Morrison,<sup>16</sup> reviewing and discussing the King method and citing his twenty-three cases, offers three steps which in his opinion are most important for the success of the operation: (1) disarticulation of the arytenoid cartilage, (2) freeing the arytenoid from the tension of the inter-arytenoid muscle and (3) fixation of the arytenoid and removal of the attached tissue in abduction for a period of time to assure one that the scar tissue will maintain it in that position.

5. Independent of King, Kelly<sup>17</sup> has devised an operation in which, by resecting a small window in the thyroid cartilage, he removes the whole arytenoid cartilage, and with chromic catgut sews the vocal cord to the external fascia. If the displacement will not be satisfactory on one side, he does the same operation on the other side. He reports many successful cases with this operation.

6. Orton<sup>18</sup> has simplified Kelly's procedure by removing a large part of the lateral portion of the thyroid cartilage in order to approach the removal of the arytenoid cartilage, which thus becomes quite accessible; in other respects he largely follows Kelly's method.

7. Woodman<sup>19</sup> approaches the crico-arytenoid joint from the posterior edge of the thyroid cartilage, claiming easier accessibility, removes most of the arytenoid cartilage except the processus vocalis, which he fastens to the inferior cornu of the thyroid cartilage with chromic catgut, which in turn is anchored to the sternocleidomastoid muscle.

At present my experience, based on few operative cases, is too limited to discuss the merit of any of these operations.

In the routine postoperative laryngeal examination I treat the patient as follows: In case only one cord is paralyzed, I ex-

amine the patient regularly at intervals of from two to four weeks. There are many spontaneous recoveries. However, if the patient's voice is hoarse, I make the Laszlo-Fiertz<sup>20</sup> test, which gives an idea of the degree of recovery expected. If the test shows that the nerve was not totally severed, I leave the patient alone; but if there are marked changes in the voice, I prescribe electric treatment. In cases in which both cords are paralyzed, I test the patient before he leaves the hospital. I resort to low tracheotomy where the opening in the glottis is 1 to 2 mm., only if there is present danger of suffocation. If there is no danger of this, I call the patient's attention to this possibility and advise him to restrict his physical exertion as much as possible, to avoid any upper respiratory infections and to enter the hospital immediately in case he notices that his breathing difficulties increase. I ask the patient to return to the clinic at regular short intervals and, in case the tests show that there is no complete severance of the nerve, I give conservative treatments of electric stimulation. A galvanic and faradic current helps many patients whose condition might be considered beyond improvement.

Most of these patients receive, besides electric stimulation, supporting therapy if signs of myxedema or hypothyroidism are present. Calcium is given, in addition to large doses of thiamin chloride, intramuscularly and by mouth. Psychosis, which is probably due to parathyroid deficiency, is encountered in cases of double paralysis; these cases present quite a problem. Blood studies are important and give some diagnostic help. The patient is observed by the combined forces of the follow-up clinic, including the surgeon, the internist and the laryngologist, as well as the neuropsychiatrist, who supervises the electric treatments. Unusual symptoms are thoroughly discussed at the weekly conferences in the thyroid department.

#### CONCLUSIONS

1. Thyroid cases undergoing operation should be checked routinely by a compe-



tent laryngologist to determine the status of the vocal cords preoperatively and postoperatively.

2. The actions of the laryngeal nerves and the muscles which they innervate are closely interwoven, therefore, it is very important that the injury to both nerves should be avoided.

3. While pressure may cause permanent damage, if it lasts a long time, experience shows that early electric stimulation may restore the function of the muscle if the nerve supply is not completely severed.

4. The cases of long standing are affected not only by the damage to the nerves, but also by the atrophy of the intrinsic muscles of the larynx and the ankylosis of the involved articulation. These conditions should be kept in mind by the surgeon who undertakes the surgical repair of the damaged vocal cords.

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# FATE OF THE URETERAL STUMP AFTER NEPHRECTOMY\*

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A REVIEW of the literature shows that there have been few comprehensive clinical and radiological surveys of the fate of the ureteral stump after nephrectomy. The need for a survey of this nature is demonstrated by the fact that the literature in the past decade has consisted chiefly of case reports concerning empyema of the ureteral stump.

The purpose of this report is to summarize the results of studies made on patients who had nephrectomies performed at the Long Island College Hospital. This series includes all service cases in which operation was performed from 1926 to and including 1944. To the present date, of the 110 patients in this group, twenty-two have consented to be investigated. An analysis of this preliminary group is presented.

Lorin, Latchem, and Otto state that the ureteral muscular wall atrophies but the mucosa remains intact if good drainage of the ureteral stump is present. If obstruction is present, the muscular wall hypertrophies. A tuberculous ureter, in contradistinction to an infected ureter of other etiology, tends to become obliterated provided no obstruction is present. This usually occurs within two years. Absorption of ureteral contents is very limited if it occurs at all. Infected ureteral contents may spread through the ureteral walls to cause peri-ureteritis. Ureteral peristalsis persists for several years after nephrectomy, but obstruction, pus, or stone must be present to initiate this peristaltic wave.

Read, Hyman, and Fronstein were among the first to conclude that stenosis of the ureteral meatus may result in empyema of the ureteral stump. Despite Marion's and Scholl's belief to the contrary, Latchem, Kidd, Hunt, and many others have shown that an impacted stone in the ureter is a frequent cause of empyema of the ureteral stump. Kuemmel believes that trauma associated with infection plays a part in the production of empyema. Gibson reported empyema of the ureteral stump resulting from obstruction secondary to ureterocele. Kimbrough believes that empyema may result when vesico-ureteral reflux is present. Smith has reported empyema which resulted from an anomalous ureteral opening. Jeck believes that besides obstruction, injury to the nerve supply of the ureter must be present to produce pyoureter of the stump. Hager and Boetticher reported a case of empyema of the stump without obstruction or stone. No satisfactory explanation of the pathogenesis of the pyoureter was given. Empyema of the ureteral stump may result regardless of the bacterial etiology of the inflammatory process of the kidney and ureter prior to nephrectomy. London and Collins state that the time interval between nephrectomy and pyoureter varies between five weeks and nine years. Brongersma and Roedelius reported cases occurring twenty-three and seventeen years, respectively, after nephrectomy. Several authors believe that empyema in these two cases may have existed for some time

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## Senger et al.—Nephrectomy

prior to diagnosis. Davison, however, has reported one case occurring seventeen years after nephrectomy. This patient was closely followed during the interim.

## METHODS OF STUDY

A preliminary cystogram was performed to determine whether or not ureteral reflux was present and to study the bladder roentgenologically. The patient was then cystoscoped and, whenever possible, the stump of the ureter was catheterized. A flat film was taken at this time. This was followed by retrograde ureterogram studies. Lastly, an intravenous urogram was performed and a ten-minute film was taken.

## RESULTS

In ten of the twenty-two cases, the ureter on the affected side could not be catheterized. Of these ten patients, a ureterogram was obtained in one by reflux following the cystogram. A catheter could not be passed in this patient due to stenosis of the orifice. A tuberculous empyema of the ureteral stump was present in this case. In one patient, a ureterogram was obtained with a Woodruff catheter. In this case, the nephrectomy had been performed for tuberculosis. In one instance, a stone was impacted in the distal ureter and, although the tip of the catheter was engaged in the ureteral orifice, no dye passed into the ureter beyond the stone. In the remaining seven cases, the ureteral orifice was sclerosed and a catheter could not be inserted. In three of these patients, a dimple was seen at the site of the ureteral orifice but no opening was present. In the remaining cases, no orifice or dimple could be seen. In one of these latter patients, a suprapubic cystotomy was done for prostatic hypertrophy at a later date and no ureteral orifice or dimple was found on the nephrectomized side. Of the eight cases in which no ureterograms were obtainable, the etiology of the renal disease for which nephrectomies were performed was as follows: There were five cases of renal tuberculosis, one patient with an infected hydronephrosis and pyelonephritis, one patient who had been nephrectomized for an ectopic kidney, and one patient with an impacted ureteral stone. The twelve cases in which the ureters could be catheterized gave the following etiological reason for nephrectomy: Cyst of the kidney (one patient), carcinoma of the kidney (one patient), calculus disease (three patients), acute pyelonephritis (two patients), subacute pyelonephritis (two patients), chronic pyelonephritis and pyelonephritis (one patient), and hydronephrosis (one patient). In the latter patient, a secondary ureterectomy was performed for urinary fistula. The pathological report on the resected stump showed a hemorrhagic ureter with very little infection. In addition to the cystoscopic findings described above, further observations of interest were noted. In those patients in whom the ureteral orifice on the affected side was patent and catheterizable, the orifice was normal. One patient, who had recovered from a severe tuberculous cystitis, showed an hour-glass bladder in which the mucosa was pearly white and numerous varicosities were present over the trigone. No ureteral orifice was visualized on the operated side. A cystocele ureteral orifice was patulous. A cystocele was present and a low-grade, non-specific inflammatory process was noted in one patient who had had a nephrectomy for renal tuberculosis. In this patient, the ureteral orifice on the affected side was occluded by a greyish white scar which protruded into the bladder. The opposite ureteral orifice was normal. In another case nephrectomized for tuberculosis, the bladder showed a chronic inflammatory process with bullous edema present over the trigone. The ureteral orifice on the operated side was slightly reddened. A catheter could not be passed through this orifice and a ureterogram was obtained through a Woodruff catheter. The other ureteral orifice was somewhat patulous.

One patient had a large, intravesical prostatic hypertrophy. In one patient who had empyema of the ureteral stump, the bladder capacity was markedly reduced. Acute inflammation of the bladder was noted in this patient. An opening of a vesicocutaneous fistula could be seen anteriorly. This was due to failure of healing of a suprapubic cystotomy wound of an operation performed two years previously for a bladder neck obstruction. The trigone was edematous. The ureteral orifice on the involved side was reddened. The opposite ureteral orifice was somewhat patulous. A mild bladder neck obstruction was present. The remaining cases had no cystoscopic findings of note.

#### RADIOLOGICAL FINDINGS

As stated above, in eight cases it was not possible to demonstrate the ureteral stump. Of the remaining patients, in three the ureteral stump was found to be narrowed and in four dilated. In one of the latter group, an empyematous ureteral stump was present. In three patients, the ureter was improved as compared to the pre-operative status but somewhat dilated. In four patients, the ureter was normal in caliber.

In five of the seven cases with tuberculosis, the ureter could not be filled. Of the remaining two patients with tuberculosis, the ureter of one was dilated and an empyema of the stump was present; the other had a simple dilatation of the ureteral stump. All of the patients who had nephrectomies performed for tuberculosis had definite tuberculous involvement of the ureter prior to nephrectomy. In the five patients in whom the ureters could not be filled, the interval since nephrectomy varied from two years and four months to eighteen years and seven months. Of the two tuberculous patients who had dilated ureters, an interval of two years and an interval of three months had passed since nephrectomy. In these cases the ureter could not be catheterized preoperatively.

Etiology of the renal disease apparently

had no bearing on the state of the ureteral stump in the other cases. It is noteworthy, however, that five of the seven cases with tuberculosis had closed ureteral stumps and that none of the seven cases showed normal ureteral stumps. Of the two patients in whom ureterograms were performed, no beading was present. In the films taken on all patients no definite ureteral peristalsis was demonstrated. No ureters in this series were found to be more dilated than before operation.

The time interval after nephrectomy varied considerably in the series and appeared to have no definite relationship to the fate of the ureteral stump except in the tuberculous cases as mentioned above.

The unusual bladder findings present in this series were few. In one patient, an hour-glass bladder was present; in another, a markedly contracted bladder was present. Both of these patients had nephrectomies for tuberculosis. Five patients had dilated bladders. The etiology for which nephrectomy had been performed appeared to have no bearing in these cases. Ureteral reflux into the stump was present in only one patient. This patient was the one mentioned above who had renal tuberculosis and in whom empyema of the ureteral stump was present. Of the remaining cases in the series, no reflux into the affected side was present; but in one case nephrectomized for tuberculosis, there was slight ureteral reflux into the ureter on the opposite side.

The intravenous urograms were performed to determine the degree of hypertrophy in the remaining kidney and changes in the pelvis and calyces. The previous films, however, were not available in most of these cases and adequate conclusions could not be drawn in many of the patients. For this reason, no further comment will be made at this time until more patients have been studied.

The age of the patient apparently had no effect on the fate of the ureteral stump. The ages at the time of nephrectomy as well as a

brief summary of each case are given below.

#### CASE REPORTS

**CASE L. M.** The urological symptoms were frequency, hematuria and right flank pain. There was no record of preoperative cystoscopy or x-ray findings. At operation, at the age of nineteen, the right kidney was removed. The kidney was enlarged and the upper pole was flabby. Nodules were present in the pelvis and upper ureter. The ureter was dilated and thickened. The pathological diagnosis was tuberculous nephritis. The time interval after the operation was eighteen years and seven months. The cystoscopic findings at this time showed the left ureteral orifice to be normal. A faint dimple was present at the site of the right orifice. X-ray findings at this time showed a normal bladder. There was some reflux of dye into the left ureter. The right ureter was apparently sclerosed.

**CASE G. S.** The urological symptoms were dysuria and right lower quadrant pain radiating to the flank. At cystoscopy before operation the catheter met an obstruction on the right at the pelvic brim. The preoperative x-rays showed an ectopic kidney on the right at the level of the iliac crest. The ureter had a right angle kink. A right nephrectomy was performed at the age of seventeen. The kidney was of the fetal type with multiple blood supply. The pathological diagnosis was congenital anomaly of the kidney. The present study was made seventeen years and four months after operation. At this time the right ureteral orifice was not seen. An early contracture of the bladder neck was present. X-ray showed a normal bladder with no ureteral reflux. The right ureter was sclerosed.

**CASE H. L.** A left nephrectomy was done at another hospital because of ureteropelvic obstruction. The patient was forty-three years old at this time. The pathological diagnosis was hydronephrosis. The present examination was performed eight years and six months after operation. At cystoscopy a low grade chronic cystitis was found. A No. 6 F. ureteral catheter was passed 25 cm. on the left. X-ray findings revealed a large bladder without reflux. A normal ureter was outlined on the left side with about one-half the renal pelvis still present. There was no evidence of urological complication, despite the fact that one-half

the renal pelvis and all of the ureter were left behind.

**CASE F. S.** The patient was operated on at the age of sixty-one at which time a left nephrectomy was performed. Multiple renal abscesses and hydronephrosis were present. The pathological report was that of an infected hydronephrosis and pyelonephritis. Five months previous to the operation fulguration of the bladder for a benign papilloma was performed and a transurethral prostatic resection was done. At that time he complained of low back pain, frequency and hematuria. Before operation, at cystoscopy, finger-like protrusions were present on the lateral bladder neck walls. These were resected. The left ureteral orifice was not visualized. The present study was performed seven years after operation. At cystoscopy, at this time, a Grade 4 intravesical prostatic hypertrophy was present. The right ureteral orifice was markedly dilated; the left orifice was not seen. X-ray studies showed a round bladder with a large defect in the base. The left ureter was apparently sclerosed.

**CASE M. W.** Preoperatively, the patient complained of frequency, burning and hematuria. At cystoscopy the bladder was found to be reddened. The ureteral orifices were normal. The catheters were passed easily. The preoperative x-rays showed areas of calcification in the upper pole of the right kidney. The calices were dilated, and destructive changes were present in the upper groups. The ureter was angulated, tortuous and moderately dilated. At the age of forty-nine a right nephrectomy was performed; the ureter was cut 8 cm. below the renal pelvis. The pathological report was that of a tuberculous kidney. The ureter was edematous, markedly thickened and measured 4 mm. in diameter. The present study was performed six years and eight months after operation. At cystoscopy the bladder showed an hour-glass deformity with a reduced capacity. The mucosa was pearly white with numerous varicosities over the trigone. The left ureteral orifice was dilated. The right orifice was not seen. X-ray studies at this time showed an hour-glass deformity of the bladder. There was no ureteral reflux. The right ureter was apparently sclerosed.

**CASE J. A.** Eight weeks previous to the operation, the patient had a bladder calculus removed. Frequency and burning were the

clinical symptoms. At cystoscopy preoperatively, the bladder was found to be chronically inflamed and ulcerations were present around the right ureteral orifice. X-ray findings preoperatively revealed a moderately enlarged right kidney. The calices were enlarged and irregularly filled. Moderate dilation of the mid-ureter was present. At the age of thirty a right nephrectomy was performed. At operation the right kidney was found to be twice the normal size. A large abscess was present in the upper pole. The ureter was dilated; it was cut as low as possible. The pathological report was tuberculosis of the kidney and ureter. The ureter was lined by squamous epithelium and small tubercles were found in the submucosa. The present study was performed six years after the operation. Cystoscopy at this time showed only a dimple in the region of the right ureteral orifice. X-ray findings revealed a normal bladder without ureteral reflux. The right ureter was apparently sclerosed.

CASE C. P. A year before nephrectomy a right nephropexy was performed. This was followed by a urinary fistula which was closed by catheter drainage. The patient at that time complained of right flank pain. Cystoscopy before nephrectomy was negative. X-rays at that time revealed a right hydronephrosis and hydroureter with periureteritis and ptosis of the kidney. At the age of thirty-one a right nephrectomy was performed. The renal pelvis was adherent to the pedicle and the ureter could not be identified. The pathological report was that of a hydronephrosis, slight. Shortly thereafter, a right ureterectomy was performed. The ureter was freed to the ureteropelvic obstruction where it was too adherent for further dissection. The ureter was cut 2 cm. above the bladder. The pathological specimen was that of a ureter 7.5 cm. long. It was not dilated and the wall was not thickened. Epithelium was intact, but extravasated red cells were present in the submucosa. Hemorrhaging into the ureter was probably due to operative trauma. The present study was performed four years and six months after nephrectomy. At cystoscopy the bladder was found to be normal. The right ureteral orifice was catheterized with ease. X-rays showed a normal bladder without reflux. The lower portion of the ureter was normal. The right ureteral stump was considered to be normal and not sclerosed.

CASE M. L. Before nephrectomy the patient's only complaint was incontinence. At cystoscopy a white plaque was found around the right ureteral orifice. A catheter was passed up the ureter with ease. X-rays at that time showed the ureter on the right to be moderately dilated. The pelves and calices were not filled. At the age of forty-one a right nephrectomy was performed. The ureter was cut as low as possible. The pathological specimen showed a tuberculous kidney and ureter. Six cm. of the ureter was present. The ureteral mucosa was entirely destroyed and replaced by tubercles. The ureter was filled with caseous material. The present study was performed four years and ten months after operation. Cystoscopy at this time revealed a low grade cystitis and bullous edema of the trigone. The right ureteral orifice was occluded by a dense, greyish-white scar which protrudes slightly. The left orifice was normal. A cystocele was present. X-ray studies showed a large dilated bladder without ureteral reflux. The right ureter was apparently sclerosed.

CASE M. N. Before operation the patient complained of right renal colic. At cystoscopy the right ureteral orifice was found to be reddened. A catheter passed with ease. Preoperative x-rays showed a calculus about 1 cm. in diameter in the right pelvis. Calices were moderately dilated. The ureter was normal. At the age of fifty-one a right nephrectomy was performed. Cysts were present in the upper pole. The ureter was normal. The pathological report was that of a subacute pyelitis. Seven cm. of ureter was present in the specimen. The present study was performed three years and ten months after nephrectomy. Cystoscopy revealed the presence of a cystocele. A No. 5 F. catheter could not be passed on the right. A No. 4 F. catheter was passed 15 cm. with ease. X-rays revealed a large dilated bladder without ureteral reflux. A narrowed ureter was demonstrated on the right. The right ureteral stump, therefore, was partially sclerosed.

CASE M. G. Before nephrectomy a mass the size of a grapefruit was found in the right upper quadrant. Cystoscopy at that time showed the right ureteral orifice to be three times the normal size. The catheter passed with ease. X-rays preoperatively showed the kidney to extend to the iliac crest. The pelvis was displaced upward and medially. The pelves and calices were dilated. There was little



FIG. 1. Case R. D. demonstrates tuberculous empyema of the ureteral stump. A stricture is present in the lower ureter.

calyceal deformity. The ureter was normal. At the age of sixty-one a right nephrectomy was performed. The pathological diagnosis was cyst of the kidney. The present study was performed three years and three months after nephrectomy. Cystoscopy at this time showed the bladder to be normal. A No. 5 F. catheter passed 10 cm. on the right with ease. X-rays revealed a normal bladder, without ureteral reflux. The right ureteral stump was normal in appearance.

CASE E. J. Previous to nephrectomy the patient complained of right flank pain and hematuria. Cystoscopy before operation revealed a normal bladder. The ureters were catheterized with ease. X-rays at that time revealed an enlarged right kidney, the lower border of which was irregular. The lower calyx was compressed. The ureter was normal. At the age of sixty a right nephrectomy was performed. The pathological specimen showed a carcinoma of the right kidney. The resected ureter was 5 cm. long. The present study was performed two years and ten months after operation. At this time the bladder was found to be normal. A No. 5 F. catheter was passed 16 cm. on the right with ease. X-ray studies revealed a large bladder. No reflux was present. The right ureteral stump was definitely narrowed.

CASE M. M. Previous to the operation the patient complained of right renal colic. At cystoscopy the right ureteral catheter met an

obstruction at the pelvic brim. X-rays revealed an opacity  $1\frac{1}{2}$  by  $\frac{3}{4}$  cm. in the right lower ureter. The ureter was irregular, dilated and tortuous. At the age of sixty-three a right ureterotomy was performed. No calculus was found. The catheter met an obstruction in the intramural ureter where the stone was impacted. The operation was not completed. Shortly thereafter a right nephrectomy was performed and 4 cm. of the ureter was resected. The pathological specimen revealed a chronic pyelonephritis. The ureter was not dilated. The present study was performed two years and five months after nephrectomy. The bladder was normal, except for slight bladder neck contracture. Only the tip of the catheter could be engaged in the right ureteral orifice. X-rays at this time showed a normal bladder without reflux. A calculus was present at the vesico-ureteral junction on the right. About two inches of the ureter was present. The ureteral stump was dilated. The patient had no symptoms despite the fact that a calculus was present in the stump.

CASE A. T. Previous to nephrectomy the patient had a left ureterolithotomy. The patient complained of night sweats and a right upper quadrant mass was present. At cystoscopy preoperatively the right ureteral orifice was edematous. A white mucopurulent plug protruded from it. The catheter passed with ease. X-rays showed the right kidney to be enlarged and low in position. Numerous areas of calcification were present. The pelvis was irregularly dilated and distorted. The upper ureter was irregularly dilated. At the age of thirty-eight a right nephrectomy was performed. The kidney was enlarged and the ureter was thickened. The pathological report was that of a tuberculous kidney. Two cm. of the ureter was present. The mucosa was completely ulcerated and replaced by round cells and giant cells. The present study was performed two years and four months after nephrectomy. At this time at cystoscopy the bladder was found to be normal. No ureteral orifice was seen on the right. X-rays showed no pathological condition involving the bladder. No reflux was present. The right ureter was apparently sclerosed.

CASE R. D. At the age of forty-one the patient had a suprapubic cystotomy and revision of the bladder neck for contracture. This was followed by a left nephrectomy. The pre-operative diagnosis was tuberculosis. The patho-

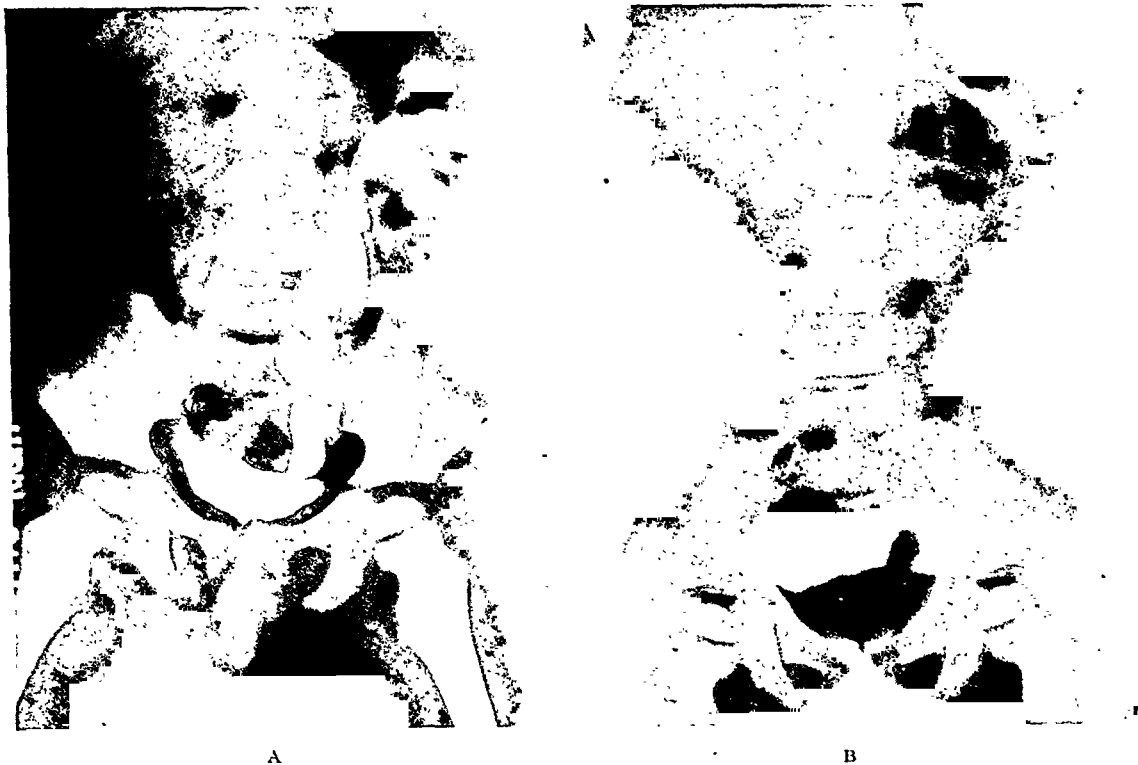


FIG. 2. Case J. C. A, preoperatively marked hydroureter is present. B, seven months after nephrectomy the ureteral stump is dilated but improved.

logical diagnosis was chronic pyelonephritis. Following this operation the patient had a persistent supra-pubic fistula. There was an occasional purulent discharge from the posterior angle of the lumbar wound. Cystoscopy showed generalized cystitis. The right ureteral orifice was dilated. A catheter could not be passed on the left. A fistulous opening was present in the anterior bladder wall. X-rays at that time revealed a small contracted bladder with reflux up the left ureter. The ureter was dilated except for the intramural portion. The right kidney showed dilatation of the pelvis, calices and ureter. At the age of forty-three a left ureterectomy was performed. About two-thirds of the ureter had been left behind at the previous operation. The ureter was found to be dilated except at its terminal portion where it was a fibrotic cord. The ureter was removed up to its junction of the bladder. The supra-pubic fistulous tract was excised. The pathological report was tuberculosis of the ureter. The ureter was 12 cm long. The lumen was filled with inspissated greyish material. The mucosa was ulcerated. The submucosa had scattered areas of tubercles. The present study was performed two months after ureterectomy. Cystoscopy revealed a chronic cystitis. The right orifice was dilated. A catheter could not be passed on the left. X-rays showed a small

contracted bladder. There was no ureteral reflux. Hydroureter and hydronephrosis were present on the right. The fistulous tract did not close. The tuberculous cystitis was treated with phenol lavages. The patient became uremic and a right nephrostomy was performed. This was followed by a suprapubic cystostomy. After the nephrostomy tube came out it could not be replaced. The patient is well to date.

CASE V. H. Before operation the patient complained of right renal colic. At cystoscopy preoperatively the catheter on the right met an obstruction at 15 cm. X-rays revealed numerous areas of calcification of the right kidney. The calices were markedly dilated. The ureter was slightly dilated and tortuous. At the age of twenty-three a right nephrectomy was performed. The pathological diagnosis was chronic pyelonephritis, hydronephrosis and calculi. The ureter was markedly narrowed at its junction with the pelvis. The present study was performed one year and eight months after operation. At cystoscopy the bladder was found to be normal. A No. 5 F. catheter passed with ease on the right side. X-rays at this time revealed a normal bladder without reflux. The lower third of the ureter was present. The upper portion was dilated and the remainder was normal.





FIG. 3. Case N. D. A, the ureter shows marked dilatation and tortuosity, preoperatively. B, post-nephrectomy the ureteral stump shows a normal caliber without tortuosity.

CASE J.' C.' Before nephrectomy the patient complained of left renal colic. Cystoscopy before operation revealed a normal left ureteral orifice. The catheter passed with ease. X-rays showed many areas of calcification in the region of the left pelvis. At the age of thirty-six a left nephrectomy was performed. The pathological diagnosis was acute pyelonephritis and calculi. The ureter was occluded by sandy material. The ureter was dilated above the obstruction. The present study was performed one year and seven months after nephrectomy. Cystoscopy revealed a normal bladder. A No. 5 F. catheter passed 16 cm. on the left with ease. X-rays showed no pathological condition involving the bladder. The ureteral stump was normal.

CASE N. D. Prior to nephrectomy the patient complained of left renal colic, chills and fever. Cystoscopy at that time showed a normal bladder. The ureters were catheterized with ease. The left kidney on x-ray showed enlargement. The pelves and calices were irregular and traces of dye extended in the parenchyma. The ureter was dilated and tortuous. At the age of sixty-four a left nephrectomy was performed. The pathological diagnosis was pyelonephritis, sub-acute. The present study was performed one year after the operation. Cystoscopy at this time revealed a normal bladder. A No. 5 F. catheter passed 15 cm. on the left. X-rays re-

vealed a normal bladder without reflux. The left ureteral stump was normal.

CASE M.' M.' Previous to nephrectomy the patient complained of right flank pain, frequency and pyuria. This had been preceded by two attacks of pyelitis in pregnancy. Cystoscopy, before operation, revealed a low-grade inflammation of the bladder. A catheter passed 12 cm. on the right. X-rays before operation showed the right kidney to be non-functioning. On retrograde pyelogram the dye extended only to the tip of the catheter. A right nephrectomy was performed at the age of thirty-four. The upper 10 cm. of the ureter was resected. The pathological diagnosis was pyelonephritis, acute. The ureter showed no disorder. The present study was performed seven months after nephrectomy. At this time the bladder was found to be normal cystoscopically. The right side was catheterized with ease. X-ray studies showed the bladder to be large. No reflux was present. The ureteral stump showed definite narrowing.

CASE J. C. Prior to the first operation the patient complained of pyuria. Cystoscopy before the operation showed a low-grade inflammation of the bladder. The left ureteral orifice was gaping and edematous. The bladder neck was contracted. X-rays at that time showed a marked hydronephrosis and hydroureter on the left. At the age of two and one-half a supra-

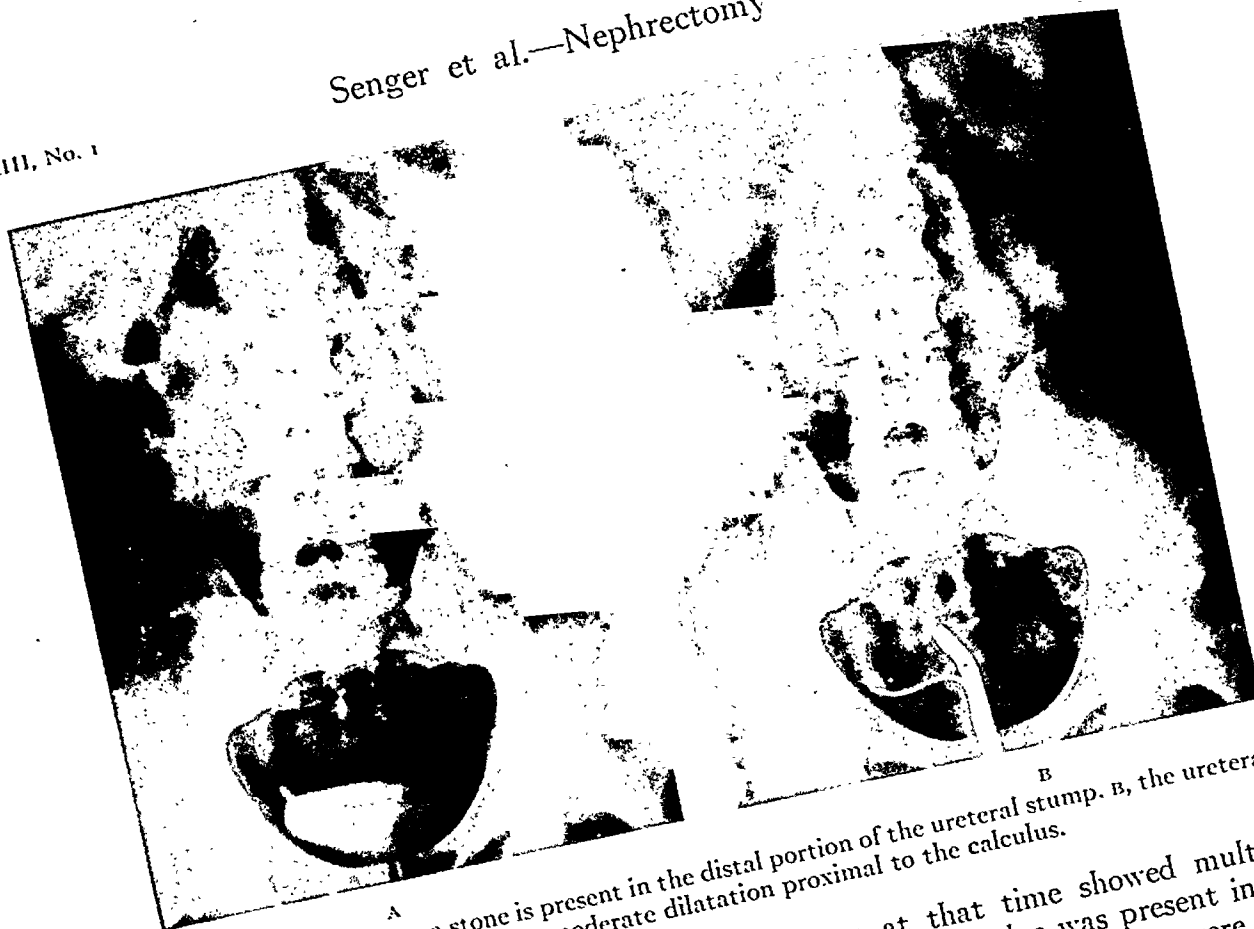


FIG. 4. Case M. M. A, a stone is present in the distal portion of the ureteral stump. B, the ureteral stump shows moderate dilatation proximal to the calculus.

pubic cystotomy and revision of the bladder neck was performed. The two left orifices were found. A pathological specimen revealed fibrosis of the bladder. Following this, there was no regression of the left hydronephrosis. Further x-ray studies revealed a double pelvis and double ureter on the left. The calices, pelves and ureters were markedly dilated. Shortly after the operation a left nephro-ureterectomy was performed. The ureter was sectioned one inch from the bladder. The ureter grossly had the size and consistency of a small bowel. The pathological diagnosis was hydronephrosis hydroureter and chronic pyelonephritis. The ureter was 8 cm. long, dilated and tortuous. Two ureters and two pelves were present. The present study was made seven months after the nephrectomy. Cystoscopy at this time revealed a normal right ureteral orifice. The left ureteral orifice was dilated. A few tags of tissue were present at the bladder neck. Only one orifice was seen on the left; this was catheterized with ease. X-rays at this time revealed a large atonic bladder without reflux. The left ureteral stump was very short and dilated. There was dilatation of the stump but this was less than on previous films.

CASE R. O. At the age of forty-three the patient had a right nephrectomy. Prior to the operation he complained of right flank pain. Preoperative cystoscopy was negative. X-ray

findings at that time showed multiple renal calculi. One calculus was present in the lower ureter. The pelvis and calices were dilated. At operation the ureter was cut as low as possible. The present study was made six months after operation. Cystoscopy showed a normal bladder. Only the tip of the catheter could be engaged in the right ureteral orifice. A calculus was found, on x-ray just above the tip of the catheter. No dye could be forced above the calculus.

CASE J. T. The patient had a right nephrectomy at the age of thirty-nine. He complained of hematuria and back pain before operation. Preoperative cystoscopy revealed a dilated right ureteral orifice which was surrounded by bullous edema. The pathological diagnosis was chronic pyelonephritis, adenoma of the kidney and calculi of the kidney. The present study was made four months after operation. A No. 6 F. catheter passed 15 cm. on the right. X-ray studies showed a normal bladder with reflux. The ureteral stump was normal.

CASE N. D. The patient had a right nephrectomy at the age of seventy-eight. Before operation he complained of hematuria of four months' duration. He had a prostatectomy two years previously and an encrustation cystitis was noted at the age of seventy-seven. Preoperative cystoscopy revealed a reddened and edematous bladder mucosa. The left orifice



FIG. 5. Case M. N. The ureteral stump shows marked narrowing. The opacities on the right are calcified lymph nodes.

was dilated. The right was surrounded by a plaque of encrustation. The catheter could be passed only  $\frac{1}{2}$  cm on the right. Preoperative x-ray studies showed dilatation of the right calices, pelvis and ureter. At operation the ureter was cut as low as possible. The pathological specimen showed tuberculosis of the kidney. The ureteral mucosa was destroyed. The ulcerated surface was lined by epithelioid cells and necrotic material. The present study was made three months after operation. Cystoscopy revealed a chronically inflamed bladder mucosa. The trigone showed bullous edema. The left orifice was reddened. A catheter could not be passed on the right side. A Woodruff catheter was used to obtain a ureterogram. X-ray studies showed no evidence of ureteral reflux. A short dilated ureteral stump was present on the right.

#### CONCLUSION

1. The ureteral stump in tuberculosis was found to be sclerosed in all the patients who had nephrectomies two or more years previously. Sclerosis was unusual in non-tuberculous patients.

2. Obstruction of the ureteral orifice was infrequent in this series. Two cases had stenosis of the ureteral orifice, one of whom had a complicating empyema of

the ureteral stump. In two, a calculus was present in the lower ureter. Neither of these had complications resulting from this.

3. Reflux into the ureteral stump occurred in only one case, that of empyema.

4. With the exception mentioned above, all ureters showed evidence of improvement as compared to the preoperative status.

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# TRAUMATIC LIPOHEMARTHROSIS

## LAYERING OF FAT AND BLOOD IN A JOINT

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THE term traumatic lipohemarthrosis has been introduced to describe the phenomenon of layering of fat and blood in a joint, which has been traumatized. The condition has only been described in the knee and there is practically always a demonstrable intra-articular fracture present. Simple hemorrhage into the joint produces a roentgenologically homogeneous fluid. When fat is liberated in large quantities in addition to blood, the fat being the lighter and more radiable of the two liquids, it layers itself above the blood and produces a fluid level. The demonstration of this layering depends upon a deviation from the usually accepted technic for radiography of the knee joint. Only films made with the patient supine and the ray directed horizontally or parallel to the plane of the layering will demonstrate it.

The principle of increased radiability of localized fat tissue and deposits is a well recognized one in roentgen diagnosis. It is utilized in the diagnosis of lipomas and of dermoid cysts of the mediastinum and ovary. The delineation of the properitoneal fat line in intra-abdominal inflammation and the fetal subcutaneous fat in localization of the placenta are well recognized diagnostic clues.

Holmgren,<sup>1</sup> in 1939, first described this phenomenon. In a case of uncomplicated intra-articular fracture of the upper end of the tibia, he observed in a lateral view of the knee made with horizontal projection of the rays, two levels adjacent to each other but at a somewhat different height, the first directly posterior, the other more anterior and proximal to the patella. His explanation was that the levels

were due to fat which had been liberated from the bone marrow and layered above the blood in the joint space. Puncture of the joint yielded hemorrhagic liquid which contained macroscopic droplets of fat. A roentgenogram made a few days later showed no level. Stimulated by the discovery of this initial case, Holmgren<sup>2</sup> made an intensive study of injuries in the region of the knee joint and in 1942 presented a very complete study covering sixty-five cases of knee injuries. He developed a special radiographic technic to demonstrate the level in the lateral view using a target-film distance of 1.5 to 2 meters with the film placed vertically 10 to 15 cm. beyond the knee and the rays directed horizontally.

Holmgren divided his cases into four groups: In the first, there were twenty-six patients in whom a fat level was demonstrated, all of whom had an intra-articular fracture of the knee. A second group of three showed fat levels without demonstrable fractures and included one patellar luxation, one with marked effusion following severe trauma and one with marked effusion following severe pain while walking. The third group consisted of fifteen fractures without a fat level, eight of them fractured patellas. The fourth group consisted of twenty-one patients with traumatic effusions but no demonstrable fracture or fat level. Nine of these were aspirated and fat droplets found in two.

The only reference to this condition in the English literature is a report in 1942 by Pierce and Eaglesham<sup>3</sup> of seven patients with fractures of the upper end of the tibia



FIG. 1. Lipohemarthrosis eighteen hours after injury. The lower limit of the fat, represented by the area of decreased density, is horizontal and approximately parallel to the long axis of the femur.

extending into the knee joint. All the knees presented major fluid levels in line with or slightly posterior to the femoral surface of the patella. Confirmation of the presence of fat in the fluid by aspiration is available in only one instance.

Kling,<sup>4</sup> in 1929, aspirated hemorrhagic fluid from traumatized knee joints. This fluid separated on standing or when centrifuged into a lower layer of cells and a layer of serum. In six of fifteen patients a supernatant layer of fat was present. All of these had internal derangement of the knee joint, complicated in three instances by intra-articular fracture of the tibia or femur: In the nine remaining instances free fat was not present and in these neither fractures nor internal derangements of the joints were demonstrated. The possibility of roentgen demonstration of a fluid level in the presence of fat and blood was not suggested by Kling.

Recently a patient was observed in whom these roentgen findings were demonstrated:

A twenty-two year old soldier, dozing while driving a car, collided with a bridge and injured the right arm and knee. Roentgenograms taken eighteen hours after the accident showed a com-

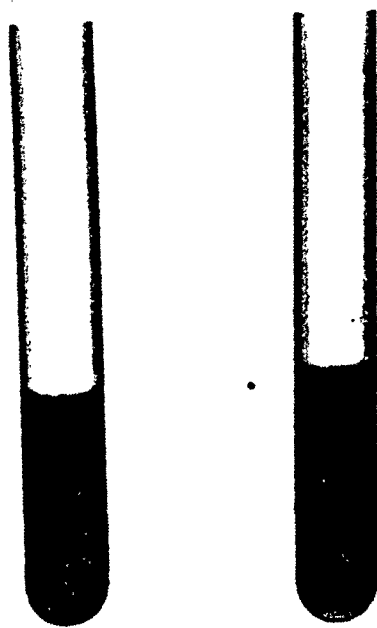


FIG. 2. Aspirated fluid. (a) The narrow upper layer is fat and is more radiolucent than the blood and serum beneath it. (b) Normal blood separated into serum and clot is roentgenologically homogeneous.

minuted fracture of the right ulna, a comminuted supra- and intercondylar fracture of the right femur with considerable displacement of the lateral femoral condyle, and an incomplete comminuted fracture of the lower pole of the patella without displacement. The lateral view (Fig. 1) made with a horizontal ray and the patient supine showed a marked swelling in the suprapatellar area and a radiolucent area proximal to the patella, its lower border characteristic of a fluid level on a line with the posterior aspect of the patella. A thin line of increased density traversed this area obliquely. Lipohemarthrosis was diagnosed, the radiolucent area representing fat in the suprapatellar region and the thin line of increased density a septum partially separating the joint space proper from the suprapatellar extension. Aspiration yielded about 25 cc. of fluid. The fluid withdrawn was first a thin, yellow oily liquid, then when the needle was inserted deeper, dark blood was aspirated. On standing in a test tube, the fluid separated into three layers, a supernatant layer of liquid fat, a middle layer of serum and at the bottom,

clotted blood. The fat solidified at 25°C. and had a specific gravity of less than 1. Radiographically, the fat appeared as a thin radiolucent band on top of the aspirated blood (Fig. 2A), in contrast to the homogeneous shadow of clotted blood and serum shown for comparison. (Fig. 2B.)

Roentgenograms (Fig. 3) taken on the following day showed a smaller radiolucent, slightly lobulated shadow in the suprapatellar space and a second radiolucent area distal and slightly posterior to the patella. The lower level was not as definite as on the previous day but remained horizontal in spite of the increased angulation of the femur. Roentgenograms on the fourth and ninth days after injury showed progressive regression of the radiolucent areas which had entirely disappeared on the eighteen-day film. Convalescence continued uneventfully. Diffuse areas of increased density suggesting calcium were first apparent around the lower end of the femur at this time but became less apparent and were absent fifteen weeks after the accident when healing was well advanced, and there was nearly normal range of motion of the knee joint.

#### COMMENTS

The recognition of traumatic lipohemarthrosis is important because of the necessity of differentiating it from other pathologic conditions, such as gas forming infections or air forced into tissues through open wounds.

A small fat body normally found at the superior pole of the patella between the joint capsule and the border of the tendon of the quadriceps muscle may be confusing when visualized roentgenologically but the fluid level characteristic of lipohemarthrosis is absent.

The possible source of this free fat in the knee joint may be from one or several of its various fat depots: these include the plicae alares, plicae synovialis, the fat enclosed within the synovial sheath of the cruciate ligaments and the marrow of its component bones. We have observed at necropsy pooling of 5 to 10 cc. of liquid fat at the site of a comminuted fracture of the tibia five days after injury, but in



FIG. 3. Lipohemarthrosis, second day after injury. The angle of the femur has been changed, the fat level remains horizontal but at an angle of approximately 40 degrees to the long axis of the femur; its size has diminished following aspiration.

traumatized adipose tissue such pooling has not been noted although minute quantities of fat apparently are released and small hemorrhagic areas are often present. Clinical observations also strongly support the theory that free fat sufficient to produce a fat level originates in the bone marrow.

In the total of thirty-seven reported patients in whom a fat level was demonstrated, only three were without demonstrable fractures. Since these fat depots are all outside the central cavity of the knee joint, the presence of fat in aspirated fluid is evidence of tearing of the synovial lining or opening of the marrow space, and its presence in quantities sufficient to produce fat levels roentgenologically is an indication of severe injury and should stimulate further search for a fracture when one is not recognized on the routine projections. Holmgren demonstrated a previously unrecognized, incomplete fracture of the tibial plateau by the use of oblique and stereo views, made because a fat level was demonstrated in the initial roentgenograms.

The effect of fat in a joint and its rate of absorption are not known. The roentgen findings of lipohemarthrosis are usually not demonstrable after one to two weeks, the result either of absorption or mixing with blood. Holmgren believed that the time of healing was not influenced by the presence of fat, but Kling recommended

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that early and repeated aspirations be carried out to avoid possible injury to the joint.

Lipohemarthrosis has been described only in the knee joint. This is probably explained by the great capacity of this joint, the size of the adjacent fat depots and the accessibility of the knee to the essential roentgen technic. It seems reasonable that it could be demonstrated in other major joints in the presence of intra-articular fracture with effusion.

None of the reported cases with a fat level showed clinical signs of fat embolism. If the clinical phenomena of fat emboli depended upon the quantity of fat liberated from the bone marrow, it would seem that this complication should become clinically apparent in these cases much more frequently.

## SUMMARY

1. In traumatized knees particularly with intra-articular fractures, fat, presumably liberated from the bone mar-

row, may layer itself above extravasated blood and produce a fluid level on the roentgenogram.

2. Recognition of this condition is important chiefly to differentiate it from serious affections of the bone such as gas-forming infections or compound fractures with air pockets.

3. The presence of a fat level is indicative of severe injury to the knee with rupture of the synovial membrane and should stimulate a search for obscure fractures not primarily demonstrable on routine projections.

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# CONVULSIONS OCCURRING UNDER ANESTHESIA\*

## ANALYSIS OF SIX CASES

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IN the recent medical literature there has been an increasing number of reports on convulsions in patients under anesthesia. Ether is the anesthetic most commonly associated with these anesthetic accidents, hence the term "ether convulsions." However, convulsions have also occurred during the administration of nitrous oxide, cyclopropane and chloroform. They have also been seen during operations performed under local anesthesia, but these convulsions are very probably the results of individual sensitivity to the given agent. Since ether is the most commonly used inhalation anesthesia in hospitals, it follows that convulsions are most commonly seen when ether is used.

During the year 1942, 2,142 anesthetics were administered on the surgical service of the Cumberland Hospital. This total can be broken down as follows: inhalation (mostly gas-oxygen-ether), 1,331; spinal, 474; local, 298; intravenous, 37; avertin, 2.

It was interesting, though unfortunate, that six convulsions occurred in patients under anesthesia during this twelve-month period. Each of the six patients received ether. The ether was administered via a closed method in four cases. In two young children, aged four and five years, ether was given by the open drop method. A spinal anesthetic (150 mg. procaine) was administered to one of the six but after a somewhat difficult gallbladder operation, anesthesia was gradually subsiding. Ether was resorted to for the completion of the intraperitoneal operation and closure of the abdominal wall. It was during this last period that the convulsion took place.

An abundance of etiologic factors have

been suggested for these convulsions. It is not the purpose of this paper to individualize and discuss these factors except as they grossly apply to the cases in question. The possible causes of this condition range from the sublime to the ridiculous. Lundy,<sup>1</sup> of Mayo Clinic, emphasizes this when he mentions the following: toxemia and septicemia, an excessive amount of carbon dioxide in the system, impurities in the ether, impurities in the oxygen, trauma, hypoglycemia, method of anesthetization, instability of the nervous system, overdosage of atropine, cerebral anemia, alkalosis, over-breathing, idiosyncrasy, cerebral vascular accident, disturbance of calcium metabolism, ketosis, heat, youth, use of oxygen, anoxemia, latent tendency to fits, changes in the blood, over-oxygenation, sex susceptibility, increased vascularity of cerebral cortex, concentrated ether, deficiency of carbon dioxide, lightness of anesthesia, deep anesthesia, hyperventilation, anaphylactic edema, hydration of protein particles in the plasma and fits produced by convulsant poisons.

Very probably, most of the above causes do not come into play in the average case of convulsions occurring in patients under anesthesia, but doubtless in each case there is a combination of a few of these factors. In the present series none of the patients had had convulsions prior to those which occurred during operation, and none of the patients gave any history of epilepsy. Several of the reported cases in the literature were not acutely ill. However, all six patients in this series were acutely ill with varying degrees of peritonitis. Probably the dehydration associated with

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the acute illness was not sufficiently corrected before operation. It is difficult to indict a single drug such as atropine, even though it was administered to the majority of patients as part of the preoperative medication, and in some instances in large doses for the given age. (Table 1.) When given in large doses, atropine is said to stimulate and then depress the central nervous system. In two cases during the convulsion; blood specimens were taken for calcium determination, but both were definitely within normal limits. No doubt, a cerebral vascular accident may well cause a convulsion on the operating table as is illustrated in this series. (Case 4, Table 1.) In a sixteen-year old white female with a ruptured appendix and generalized peritonitis, the postoperative course was characterized by a hemiplegia which per-

sisted for one day after operation and a facial paralysis associated with difficulty in speech for sixty-two days. Undoubtedly, these signs were brought about by organic brain disease but it cannot be stated whether these changes precipitated the convulsion or were consequent to it. It is not illogical to assume that operative trauma might precipitate generalized convulsions in an acutely ill, dehydrated, toxic individual who is lightly anesthetized. Following the suggestion of Tye,<sup>2</sup> anesthesia was deepened in one of the patients after the convulsion had persisted for nearly ten minutes. Shortly thereafter the convulsion ceased. Yet some authors deny that lightness of anesthesia is an etiologic factor.

The method of anesthetization appears to be a variable factor as a cause of

TABLE I

Case Number	1	2	3	4	5	6
History on admission	7/42 61 yr. W. M. No vomiting 5 days. Dehydrated. T.P.R. 101.6 90 28.B.P. 120/84	9/42 15 yr. W. F. 12 hrs. vomited numerous times. Dehydrated. T. P.R. 100.4 92 24 B.P. 128/80	4/42 14 yr. W. M. Dehydrated T.P.R. 101 120 24. B.P. 120/~0	2/42 16 yr. W. F. 36 hrs. Vomited 4 times. Dehydrated. T.P.R. 100.6 95 20 B.P. 130/75	9/42 5 yr. W. F. 18 hrs. Vomited 3 times Diarrhea. Dehydrated. T.P.R. 105.2 140 36	10/42 4 yr. W. M. 48 hrs. Vomited 3 times. Not dehydrated. T.P. R. 100.8 120 28
Physical findings	Pathology RUQ Mild ilius. Mild jaundice. No record acetone	RLQ pathology No acetone	RLQ pathology. No acetone	Rigid abdomen 2 plus acetone	Rigid abdomen No acetone	RLQ pathology No record acetone
Time before operation	4 hours	10 hours	6 hours	2 hours	8 hours	4 hours
Preoperative treatment	Intravenous 800 cc. 5% G/S; Atropine gr. $\frac{1}{150}$ ; MS gr. $\frac{3}{4}$ ; atropine gr. $\frac{3}{150}$ ; MS gr. $\frac{3}{4}$ ; Scopamine gr. $\frac{3}{150}$	Intravenous 500 cc 5% G/S; Nembutal, gr. $\frac{3}{4}$ ; MS gr. $\frac{3}{4}$ Scopamine, gr. $\frac{3}{150}$	Intravenous 1000 cc 5% G/S; MS gr. $\frac{3}{4}$ ; Atropine, gr. $\frac{3}{150}$	Intravenous started MS gr. $\frac{3}{4}$ ; atropine gr. $\frac{3}{150}$	Plasma 150 cc. Saline 150 cc. Codeine gr. $\frac{3}{4}$ ; Atropine gr. $\frac{3}{150}$	No intravenous; Codeine gr. $\frac{3}{4}$ ; Atropine gr. $\frac{3}{150}$
Anesthesia	Spinal. Ether during closure	Gas-oxygen-ether	Gas-oxygen-ether	Gas-oxygen-ether	Gas-oxygen induction. Ether operation	Gas-oxygen induction. Ether operation
Operation	Acute suppurative gangrenous gallbladder	Acute suppurative gangrenous appendix	Acute suppurative gangrenous appendix. Generalized peritonitis.	Acute suppurative appendix. Generalized peritonitis.	Acute suppurative appendix. Generalized peritonitis	Acute suppurative appendix
Operative time including convulsion	108 minutes	65 minutes	55 minutes	60 minutes	45 minutes	50 minutes
Time, type and length of convulsion	Closure. General clonic. "Several minutes."	Closure. General clonic. 25 min.	Exploration. General clonic. 15 min.	Exploration. General clonic. 20 minutes	Exploration. General clonic 10 minutes	Closure. General clonic. 15 minutes
Treatment	6 cc. 5% sodium pentothal.	CA gluconate 10 cc. Sodium pentothal gm. 5	Sodium pentothal gm. .4	CA gluconate 20 cc. 10% sodium pentothal 25 gm.	Deeper anesthesia	Anesthesia stopped Oxygen C Agluconate 10 cc. 10%
Complications	Hepato-renal disease. Died 5th day. Disoriented throughout.	None. 3 plus acetone P.O. Discharged 12th day	3 day lethargy. Discharged 29th day	P.O. intermittent convulsions 18 hrs. Hemiplegia, facial 1 day. Discharged 62nd day	Wound infection Discharged 28th day	Wound infection. Discharged 29th day

convulsions. Closed anesthesia apparatus was employed on four patients and open drop ether on two in this series. Many writers strongly support the theory that fatalities are due to cerebral anoxemia resulting from the convulsion which in turn was caused by hyperventilation. Some reported cases with autopsy findings showed degenerative changes in the cells of the basal ganglia, presumably resulting from anoxemia. Incidentally, it may be significant to note the following facts: At the Cumberland Hospital inhalation anesthetics are administered by trained nurse anesthetists, there being a staff of five. It happened that only two of the nurses participated in this series. Each anesthetized three of the six patients. This may be purely coincidental. Finally, it may be said that with such a large number of possible causative factors, most of which vary greatly in each individual case, it is extremely difficult to place blame on any one cause. Suffice it to say that prophylaxis, prompt recognition and prompt treatment are of paramount importance.

Most of the convulsions occurring during anesthesia are said to occur in children or young adults. This was true of the present series with the exception of a sixty-one-year old white male. Although the incidence of these convulsive seizures is said to be slightly higher in the female, there were an equal number of male and female patients in this group. The convulsions are usually clonic in type and in the average case start in the eyelids, then involve the face, the neck, the upper and lower extremities progressively. Woolmer and Taylor<sup>3</sup> described the classical symptoms as follows:

"The patient is a child or young adult with pyrexia, usually due to some acute septic condition. The theater is overheated. Atropine has been given and the dose may have been excessive. The patient is deeply anesthetized with ether, the pupils being dilated and inactive to light. The color is, as a rule, good and oxygenated ether is sometimes being given. The eyelids start

to twitch, then the face, and the convulsions become general. In the immediately fatal cases, after five to ten minutes of convulsions, the respiration ceases, the patient goes blue, and the heart stops; in other cases, the convulsions stop but the patient dies later from cardiac failure; alternatively, recovery may follow the cessation of the convulsions."

The convulsions usually occur shortly after the opening of or during the closure of the peritoneum. There were three such instances in this series.

The reported percentage of mortality in cases of convulsions occurring under anesthesia varies between fifteen and fifty per cent. There was only one death in this series and it was not attributed to the convulsion. (Case 1, Table 1.) The patient, a sixty-one year old male with a gangrenous gallbladder, succumbed on the fifth postoperative day from a rather typical hepatorenal failure. Unfortunately, permission for autopsy was not obtained. The remaining patients made eventual complete recoveries with no sequelae.

In every case of emergent abdominal surgery, a sensible parental administration of necessary fluids should be given as a preoperative measure. The peritoneal damage incurred during the several hours necessary for this preoperative care is not so great that the patient should be rushed to the operating room. This is particularly true since the advent of chemotherapy for intraperitoneal use. Plasma, if necessary, should be given in addition to the usual electrolytes, depending upon hematocrit readings, acetonuria and plasma "falling drop" determinations or blood plasma readings, if available. It is fully realized that many hospitals do not have all of these means on hand both day and night. Nevertheless, every possible effort should be made to correct dehydration, hemoconcentration and acidosis before operation. Experience with these patients has taught the authors much in this respect. In the literature the incidence of convulsions associated with spinal anesthesia

is negligible compared to that with inhalation anesthetics. It is worth while to consider the use of spinal anesthesia in these toxic individuals, even though the patient be young, since if judiciously administered it may be given safely even to children. Overheating of the operating room and of the patient by too many blankets and sterile drapes should be avoided. Whether atropine is a causative factor in convulsions of this type is a moot question. It should perhaps be given in smaller dosage than the individual case calls for. Hyperventilation should be avoided in order to prevent the too rapid loss of carbon dioxide and the development of alkalosis. Finally, the necessary equipment for the speedy intravenous administration of sodium pentothal should be on hand in the operating room, particularly if the case in question is of the aforementioned toxic group.

If a convulsion occurs during anesthesia, the following measures should be adopted quickly: Stop the anesthesia but maintain a satisfactory airway; stop the operation; take rectal temperature and if above 103°F., sponge the patient. In addition, if the position of the patient on the table is other than that of normal dorsal recumbency, such as lithotomy, on a gallbladder rest, quickly place the individual in the natural recumbent position. Finally, but most important of all, administer intravenously a few cubic centimeters of a 2.5 per cent solution of sodium pentothal. Less than 0.5 Gm. is all that is necessary and this will quickly suppress the convulsion. If the latter occurred during or near the time of closure of the abdomen, probably no further anesthesia will be necessary. If the convulsion occurred shortly after the onset of operation and further anesthesia is actually necessary, it is safe to readminister the anesthetizing agent. Apparently the patient resumes a physiologic balance during the treatment period. Naturally, the operation should be completed as quickly as is feasible.

In four of the six patients, the con-

vulsions immediately ceased following the administration of sodium pentothal. It must be said that there was procrastination with other measures before such administration, a mistake which will not happen in the future should the occasion arise. Intravenous calcium gluconate was tried on three patients with no success. Once anesthesia was deepened with apparent success. Such a procedure is not advised inasmuch as it is questionable and because there is such a valuable agent as pentothal sodium on hand.

#### SUMMARY

Convulsions during anesthesia are rather uncommon but it is important for physicians to be on the alert to treat these unfortunate occurrences and prevent them if possible. Six convulsions during anesthesia were encountered in one year.

The etiology of these convulsions is extremely vague. The literature is replete with possible causes, many of which contradict each other, thereby making the situation more confusing.

Despite lack of knowledge concerning the causative factors, we should give strict attention to the preoperative care of our patients, particularly those who are acutely ill and toxic, thereby very likely lessening the number of convulsions during anesthesia. The authors recommend the prompt administration of sodium pentothal as advocated by Lundy.

Heretofore the mortality in patients having convulsions during anesthesia was extremely high. With sodium pentothal at hand, this figure should be lower. There was only one death among the six patients herein presented and this was attributable, not to the convulsion but to hepatorenal failure on the fifth postoperative day.

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# CLASSICAL HERNIORRHAPHIES OF BASSINI, HALSTED AND FERGUSON

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THE original papers by Bassini, Halsted and Ferguson, dealing with the operative treatment of inguinal hernia, are not only of great historical interest, but also of great practical value to the student of the operative technics for inguinal herniorrhaphy. It was, therefore, thought to be of interest to bring together in one paper the essential features of the original papers by these surgeons, for the most part, in the original words of the authors.

The Bassini repair for inguinal hernia described fifty-seven years ago was the key to this problem which had baffled all previous surgeons. Further, the Bassini repair of 1889 is as modern as 1946 and will continue to be modern until further evolution of man changes the congenital defect in the lower abdomen which makes inguinal hernia possible.

All drawings are from the originals and are exact in detail and in number except for those accompanying Ferguson's paper. The essential drawings from his original article and his book on hernia were selected to illustrate his operation here.

The papers are discussed chronologically. It is believed that Bassini's paper, presenting 251 cases operated over a previous period of  $4\frac{1}{2}$  years, dated "Padua, den 30. Juli 1889," but not published until 1890, should be placed first, from a chronological standpoint, while Halsted's five cases, representing a period of six months' work and published December, 1889, is placed second. Halsted radically changed his operation of 1889 until 1903 when he revealed a totally different type of operation for the repair of inguinal hernia, while

the Bassini herniorrhaphy has remained the same through the years.

BASSINI<sup>1</sup> 1889

Dr. Edward Bassini began his famous paper of 1889 as follows: "After all that has been written with such feverish diligence up to the present time concerning the radical cure of inguinal hernia it would certainly appear hazardous to publish something further on this subject. I resolved, therefore, to take up the treatment of this difficult and delicate theme only because I can illuminate the problem by demonstrative facts and diligent investigations on patients."

Bassini discusses the types of operations in vogue at that time, the high recurrence rate prevalent with these operations, the necessity of wearing a truss after operation, and briefly, his own experience with these operations. Of the operations prevalent at that time for the repair of inguinal hernia, Wood's and Czerny's were the most popular. "Of the numerous methods of operative approach which have been described for the radical treatment of inguinal hernia, only those of Wood and Czerny are in use at the present time . . . as well as the modifications of these operations by the different surgeons which do not essentially change the above mentioned methods of operation. Wood closes the enlarged inguinal canal, in which he invaginates a part of the hernia sac and closes the wall of the inguinal canal and the crus of the external opening over this invaginated part. Czerny, on the other hand, removes the hernia sac, lets the neck retract and closes the external inguinal ring with deep (buried) sutures. Wood's method is only applicable with

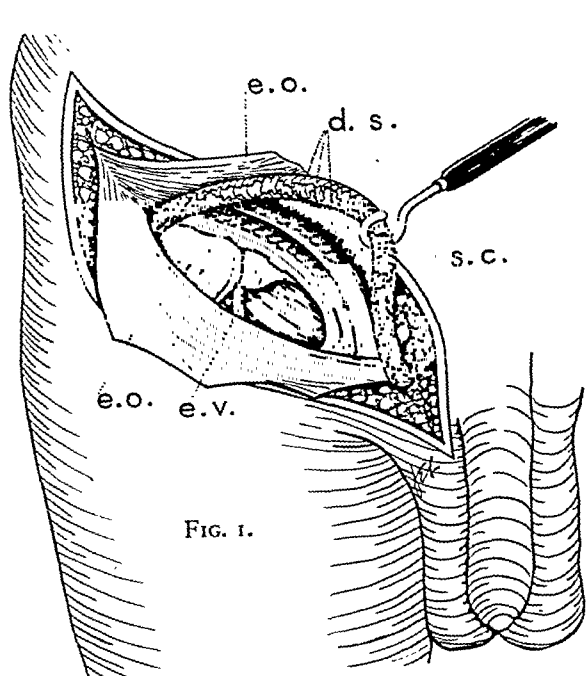


FIG. 1.

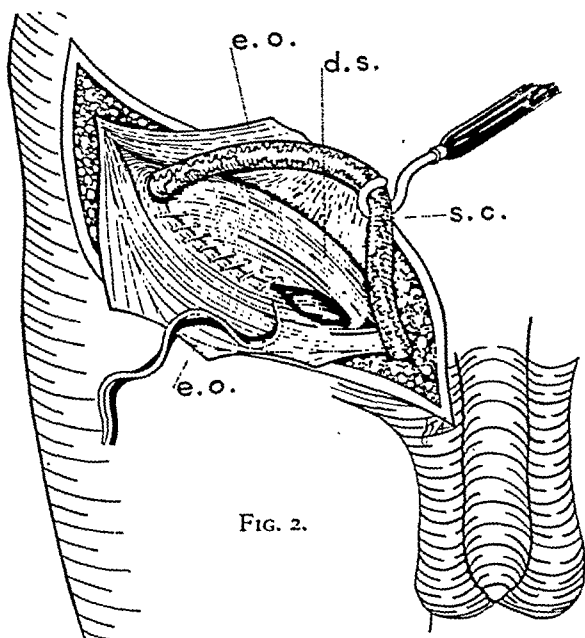


FIG. 2.

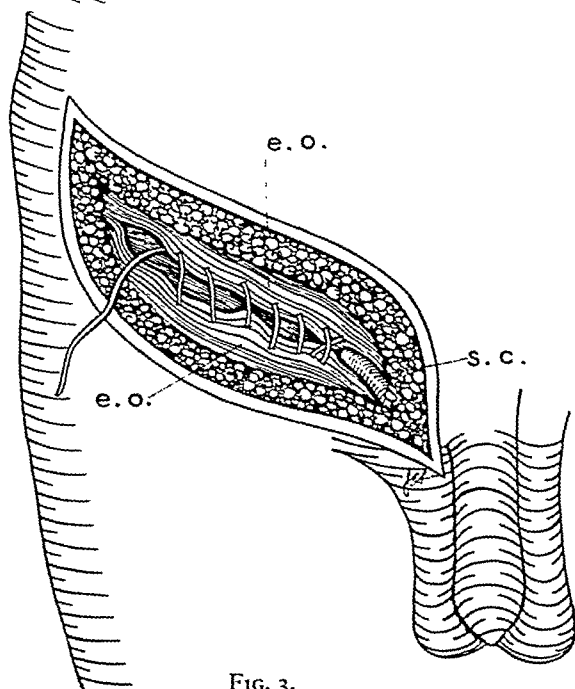


FIG. 3.

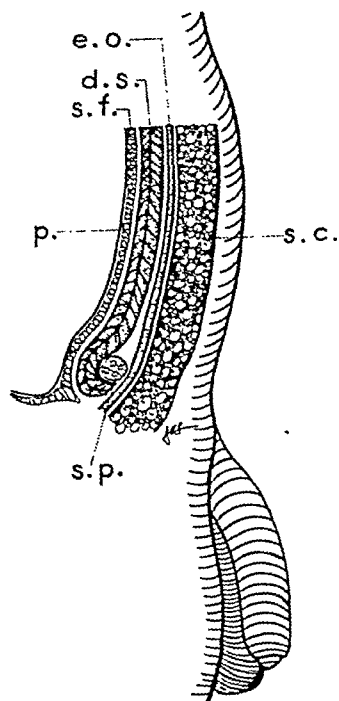


FIG. 4.

FIG. 1. Bassini 1889 plate 1. Throughout these drawings of Bassini, Halsted and Ferguson the same lettering means the same thing and is to be interpreted as follows: d. s., dreifache Schicht—internal oblique abdominal muscle plus the transverse abdominal muscle plus the transversalis fascia; e. v., epigastric vessels; e. o., aponeurosis of the external oblique muscle; i. o., internal oblique muscle; p. l., Poupart's ligament; s. c., spermatic cord; v., vein; v. d., vas deferens; c. t., conjoined tendon; c., cremaster muscle; sac—the hernial sac; p., peritoneum. In all of these drawings the details of the illustrations accompanying the original article have been retained.

FIG. 2. Bassini 1889 plate 2. The internal oblique and transverse muscles and the transversalis fascia is being sewed to the "hinteren Rand des Poupart'schen Bandes." A continuous suture is shown as in the original but Bassini used interrupted sutures.

FIG. 3. Bassini 1889 plate 3. The closure of the aponeurosis of the external oblique muscle over the spermatic cord. Here also Bassini used interrupted sutures.

FIG. 4. Bassini 1889 plate 4. Sagittal section of the abdominal wall after the completion of a Bassini herniorrhaphy showing the spermatic cord lying between the aponeurosis of the external oblique muscle in front and the "dreifache Schicht" behind and below; s. f., subserosal fat; s. c. subcutaneous tissue.

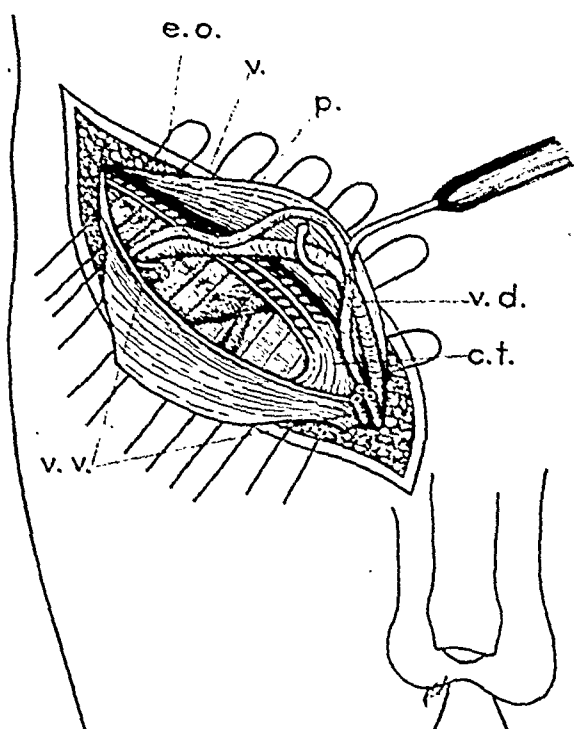


FIG. 5. Halsted 1893 plate 1. v. v., stumps of excised veins. The hernia sac has been cut away, the veins of the spermatic cord excised and the peritoneum closed with interrupted sutures. Six (or eight) interrupted mattress sutures are shown which "pass through the aponeurosis of the external oblique, internal oblique and transversalis muscles and transversalis fascia and Poupart's ligament and fibers of the aponeurosis of the external oblique muscle on the other."

the reducible hernia, not with the irreducible hernia. Therefore it has a limited applicability."

Explaining the plan of his operation Bassini wrote: "I conceived the idea that a radical cure might be obtained by a reconstruction of the inguinal canal, as it exists in the physiological condition, that is, a canal with two openings, one abdominal and one subcutaneous, further, with two walls, one posterior and one anterior, through the middle of which the spermatic cord would pass obliquely. With the aid of the anatomical knowledge of the inguinal canal and inguinal hernia, obtained by dissections of cadavers, it was easy for me to find a method of operation which fulfilled the above mentioned requirements and made possible a radical cure without the necessity of wearing a truss. According to this method, which I have used exclusively

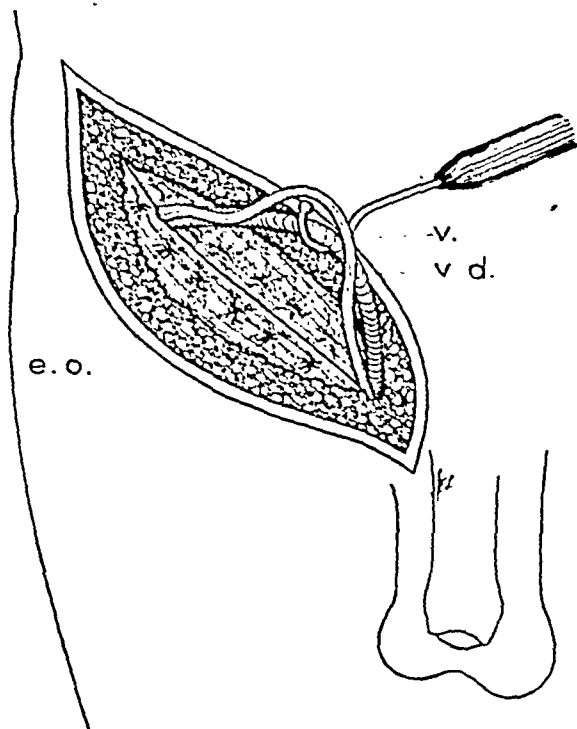


FIG. 6. Halsted 1892 plate 2. After tying the mattress sutures the vas deferens and one vein are seen outside of the aponeurosis of the external oblique muscle. Halsted uses only one row of sutures, (besides the row used to close the peritoneum). He says: "to secure for the cord the position which Bassini recommends an additional row of stitches is required. Unless it should be demonstrated by a comparison of the results of the two methods that there is something to be gained by these additional stitches, it would be well for the sake of the wound and the operator to discard them."

since 1884 and which I will now describe, I have operated on 262 hernias, 251 of which were reducible and irreducible and 11 strangulated."

Using antiseptic technic Bassini divides his operation into four parts.

"1. I incise the skin in the inguinal-scrotal region, exposing the aponeurosis of the external oblique muscle over the inguinal canal, exposing the cruri of the subcutaneous inguinal ring, and 'stille die Blutung.'

"2. I cut through the aponeurosis of the external oblique muscle from the subcutaneous inguinal ring to the abdominal inguinal ring, free up the two leaves of the aponeurosis of the external oblique muscle, isolate and raise up, in toto, the spermatic cord and the neck of the hernia

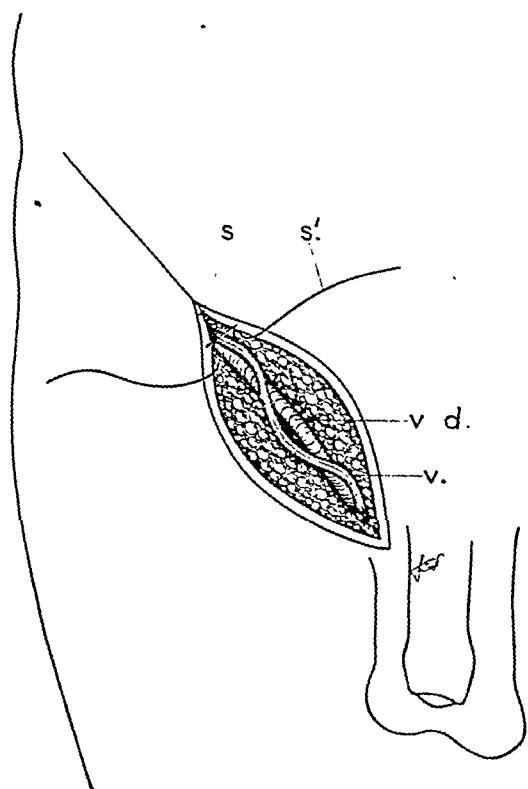


FIG. 7. Halsted 1893 plate 3. s., buried skin-stitch, tied. s', buried skin-stitch, introduced but not tied. Halsted wrote in a footnote; "Instead of the interrupted buried skin suture as shown in Plate 3, we now use an uninterrupted buried skin suture without knots, which is withdrawn after two or three weeks." The transplanted cord lies on the aponeurosis of the external oblique muscle and is covered by skin only.

sac. With the forefinger under these structures, I isolate the neck of the hernia sac up to the mouth of the hernia from the elements of the spermatic cord. The separation proceeds without great difficulty with blunt instruments when one is dealing with an acquired or congenital hernia. The separation of the neck of the sac must be extended into the iliac fossa, above the mouth of the sac itself. Similarly I isolate the body and the base of the sac, open the base of the sac and look for adhesions holding viscera in the hernia or if the omentum is thickened. If this is the case I cut the adhesions and remove as much of the omentum as is necessary. After the replacement of the viscera I twist the neck of the sac, place a tie on the other side of the mouth and amputate the sac  $\frac{1}{2}$  cm. from the ligature. When the hernia is very

large and the neck and mouth of the sac are broad, I place, besides the simple ligature, a purse-string suture to safeguard the closure and to prevent the slipping off of the tie.

"3. I retract the isolated spermatic cord, placing it gently on the abdominal wall. I do the same, when it is necessary, with the testicles, which would be pulled out of the scrotum; with sharp and broad hooks I retract the lower leaf of the aponeurosis of the external oblique muscle downward, the upper leaf upwards, and in this manner one succeeds in exposing the groove which is formed by Poupart's ligament until its posterior edge and one cm. above the place where the spermatic cord comes out of the iliac fossa are exposed; next I free up the external edge of the rectus abdominis muscle and the threefold layer which is formed by: Musculus obliquus internus, M. transversus, Fascia verticalis Cooperi (the fascia transversalis), from the aponeurosis of the external oblique muscle and from the subserosal adipose tissue until the threefold layer can be sewed to the posterior edge of Poupart's ligament without difficulty. After this is done I sew these two parts together with interrupted sutures, for a length of 5 to 7 cm., from the crest of the os pubis to the point of emergence of the spermatic cord, which is shifted about 1 cm. towards the anterior superior iliac spine. With this the third part of the operation is finished and the internal or abdominal inguinal ring and the posterior wall of the inguinal canal are restored.

"It is advisable to use interrupted silk sutures and to sew 2 to 3 cm. from the edge of the threefold muscular-aponeurotic layer. The first two sutures beginning close to the os pubis also take in the outside edge of the rectus abdominis muscle. If the operation were to end at this point, one could see, if the patient be stimulated to vomit, (I have tried this on my first 50 cases) that the inguinal region is able to withstand the strongest intra-abdominal pressure, and that the three-fold muscular-aponeurotic

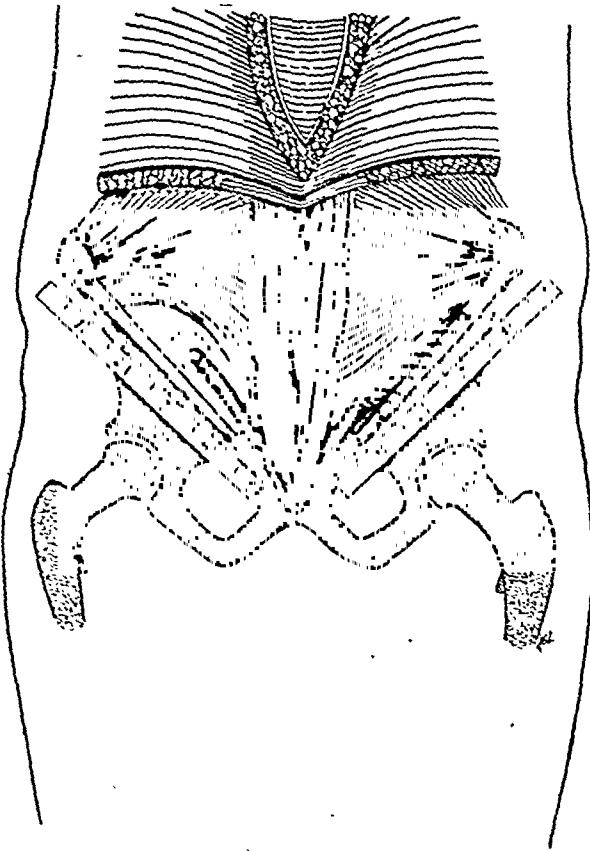


FIG. 8. Ferguson plate 1, 1899. Ferguson's original article is abundantly illustrated by eleven drawings which show every step from the line of incision to the skin closure. In his book of 1907 he uses the drawings, whose essential features are shown here to illustrate his herniorrhaphy. "The author considers the congenitally deficient origin of the internal oblique and transversalis muscles one of the most frequent and important causes of oblique inguinal hernia."

layer fixed to Poupart's ligament is stretched tightly but remains unchanged in its new position.

"4. I place the spermatic cord in its place, also the testicles, suture together the aponeurosis of the external oblique until the edges are sewed together down to the cruri of the spermatic cord, and unite the skin, finally put on the bandage."

Bassini summarizes his case as follows:

Healed from 1 to 4½ years...	108 cases
Healed from 6 months to 1 year	33 cases
Healed from 1 to 6 months....	98 cases
Recurrences.....	7 cases
Unknown results.....	4 cases
Death from other cause 15 days postoperatively.....	1 case
	<hr/> 251 cases

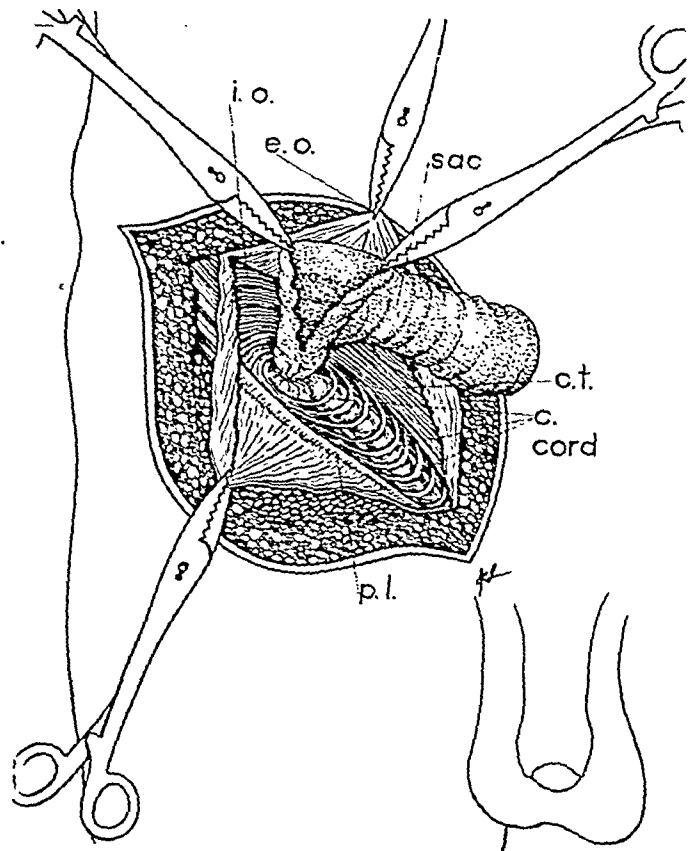


FIG. 9. Ferguson plate 2, 1899. The opening and inspection of the inside of the hernia sac.

HALSTED,<sup>4</sup> 1893

At the staff meeting of the Johns Hopkins Hospital faculty on November 4, 1889, Wm. S. Halsted, Professor of Surgery of that institution, presented five patients on whom he had performed a new type of operation for the cure of inguinal hernia. The first operation had been done on June 13, 1889. It is of interest that this operation was published in the first issue of the Johns Hopkins Hospital Bulletin and shortly after the opening of the hospital. Also of interest is Case 3, operated August 16, 1889. In this case Halsted notes on August 26th: "Passes urine through wound. Infer that one of the deep sutures was passed through the wall of the bladder," and on September 4th: "Patient passes all of his urine through the penis."

The operation is described as follows:<sup>2</sup>

"1. The incision begins at the external abdominal ring, and ends one inch or less (less than one inch in children) to the inner side of the anterior superior spine of the ilium on an imaginary line connecting



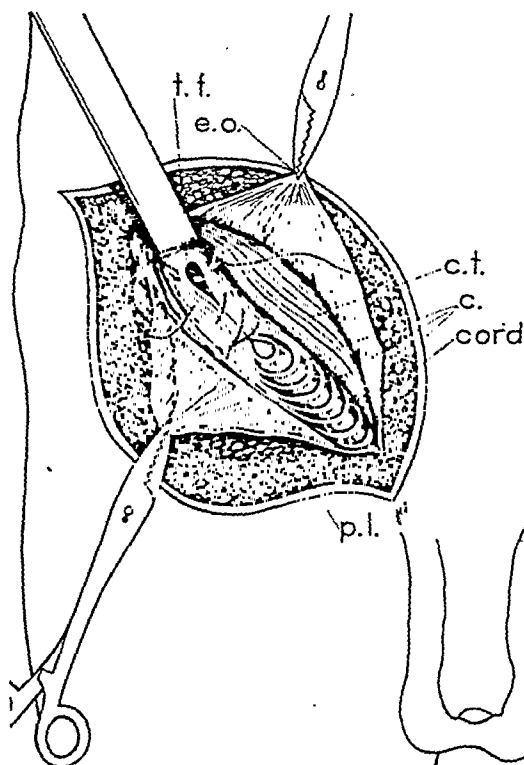


FIG. 10. Ferguson plate 3, 1899. "The cremaster muscle is allowed to hug the cord and is re-attached to the internal oblique muscle. The transversalis fascia forms the internal ring. In hernia its fibers have become more or less stretched above and around the cord. To rectify this condition take up the slack in the fascia by means of a suture, interrupted or continuous."

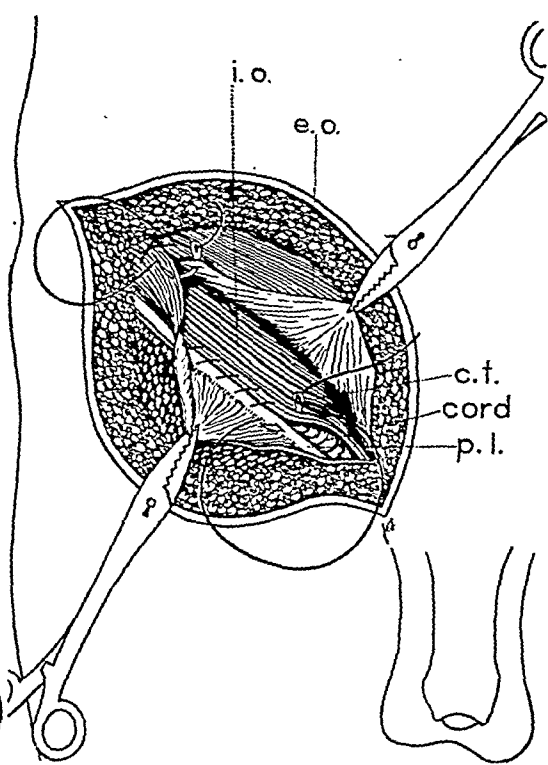


FIG. 11. Ferguson plate 4, 1899. "Suture the internal oblique and transversalis muscles to the internal aspect of Poupart's ligament, and restore their normal origin. The external edges of the aponeurosis of the external muscle are brought together in lateral folds or by overlapping."

the anterior superior spines of the ilia. Throughout the entire length of the incision everything superficial to the peritoneum is cut through.

"2. The vas deferens with its vessels is carefully isolated up to the outer termination of the incision, and held aside.

"3. The sac is opened and dissected from the tissues which envelope it.

"4. The abdominal cavity is closed by quilted sutures passed through the peritoneum at a level higher by  $1\frac{1}{2}$ -2 inches, than that of the so-called neck of the sac.

"The vas deferens and its vessels are transplanted to the upper outer angle of the wound.

"6. Interrupted, strong silk, suture, passed so as to include everything between the skin and the peritoneum, are used to close the deeper portion of the wound,

which is sewed from the crest of the pubes to the upper outer angle of the incision. The cord now lies superficial to these sutures, and emerges through the abdominal muscles about one inch to the inner side of the anterior superior spine of the ilium.

"7. The skin is united over the cord by interrupted stitches of very fine silk. These stitches do not perforate the skin and when tied they become buried."

By February 17, 1891, Halsted had performed this operation twenty-one times.<sup>3</sup> His more authoritative paper, from the aspect of time and cases, appeared in 1893 with a collection of fifty-eight cases.<sup>4</sup> In this paper he gave a historical review of the operations for inguinal hernia and then describes his operation.

"Bassini's operation and mine are so nearly identical that I might quote his results in support of my operation. Instead of trying to repair the old canal

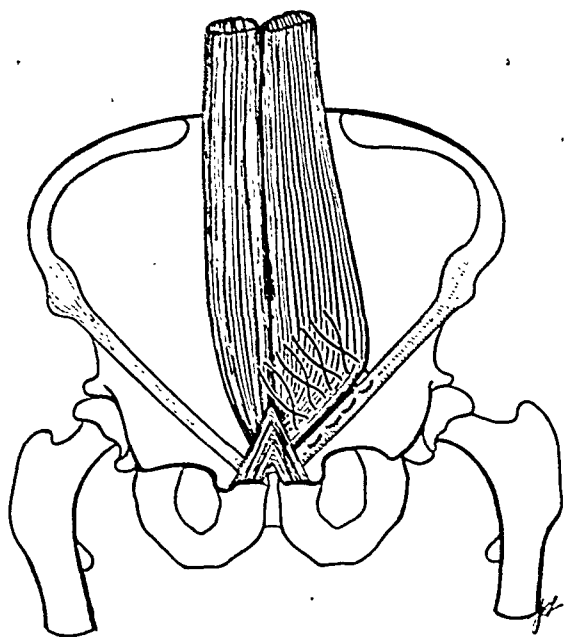


FIG. 12. Ferguson plate 5, 1899. "If the conjoined tendon is deficient or absent, or if a direct hernia co-exists, the sheath of the rectus muscle is opened freely down to the pubic bone and the muscle brought across the weak point to Poupart's ligament." This is known as Bloodgood's operation and is given in the very extensive article; "Operations on 459 Cases of Hernia, etc. in the Johns Hopkins Hospital from June 1889 to January, 1899," by Jos. C. Bloodgood M.D., the Johns Hopkins Hospital Reports, Vol. 7, 1898-99, pp. 224 to 561.

and the internal abdominal ring, as McEwen had tried to do, I make a new canal and a new ring. The new ring should fit the cord as snugly as possible, and the cord should be as small as possible. The skin incision extends from a point about 5 cm. above and external to the internal abdominal ring to the spine of the pubes. The subcutaneous tissues are divided so as to expose clearly the aponeurosis of the external oblique muscle and the external abdominal ring. The aponeurosis of the external oblique muscle, the internal oblique and transversalis muscles and the transversalis fascia are cut through from the external abdominal ring to a point about 2 cm. above and external to the internal abdominal ring. The vas deferens

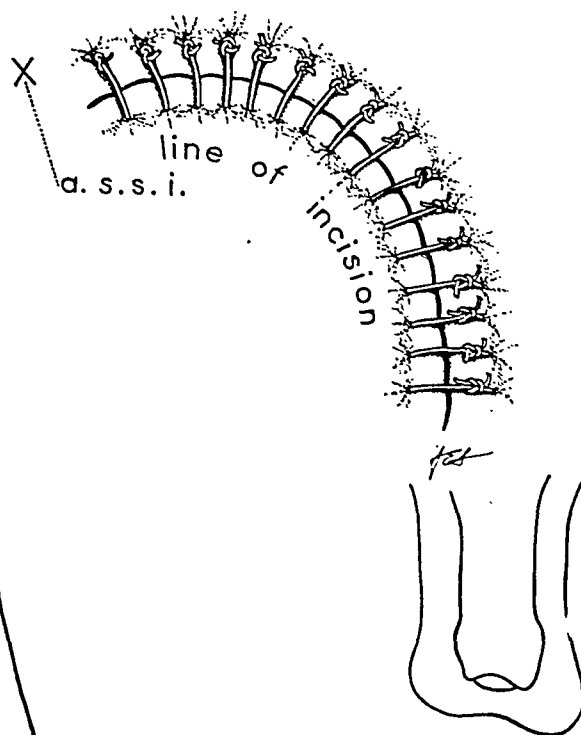


FIG. 13. Ferguson plate 6, 1899. Ferguson was very fond of the semilunar incision; a. s. s. i., anterior superior spine of the iliac bone.

and the blood-vessels of the cord are isolated. All but one or two of the veins of the cord are excised. The sac is carefully isolated and opened and its contents replaced. A piece of gauze is usually employed to replace and retain the intestines. With the division of the abdominal muscles and the transversalis fascia the so-called neck of the sac vanishes. There is no longer a constriction of the sac. The communication between the sac and the abdominal cavity is sometimes large enough to admit one's hand. The sac having been completely isolated and its contents replaced, the peritoneal cavity is closed by a few fine silk mattress sutures, sometimes by a continuous suture. The sac is cut away close to the sutures. The cord in its reduced form is raised on a hook out of the wound to facilitate the introduction of the 6 or 8 deep mattress sutures, which pass through the aponeurosis of the external oblique muscle and through the internal oblique and transversalis muscles and the transversalis fascia, on the one side and Poupart's ligament and fibers of the aponeurosis of the external oblique muscle on the other.

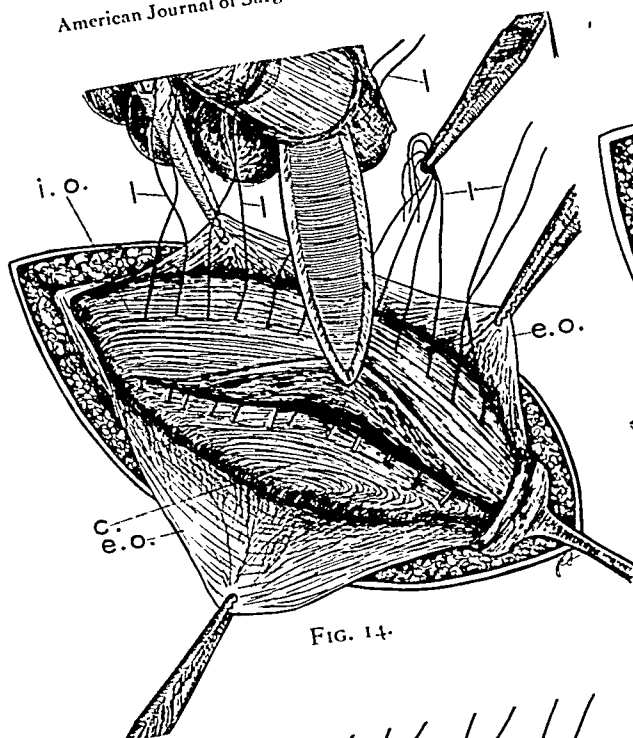


FIG. 14.

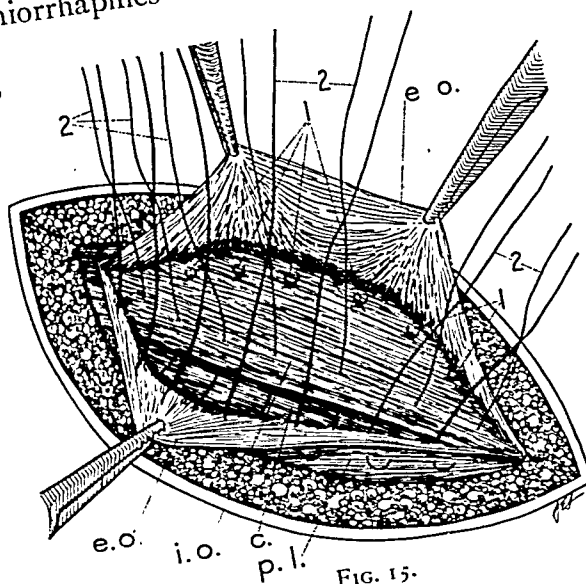


FIG. 15.

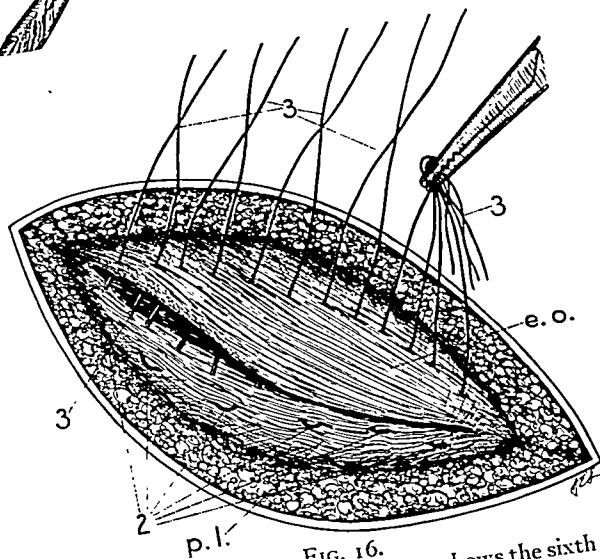


FIG. 16.

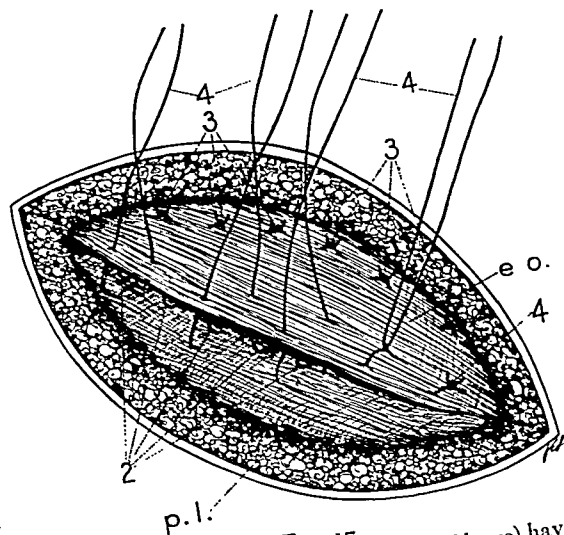


FIG. 17.

FIG. 14. Halsted 1903, plate 1. Plate 1 shows the sixth step of the operation. The veins of the cord (if large) have been carefully excised, without injury to the vas deferens. The hernia sac has been cut away and transplanted "far out under the internal oblique muscle." Here the lower flap of the cremaster muscle and fascia has been drawn up under the internal oblique muscle by very fine silk stitches. The vas deferens, being left in its natural bed is, therefore, covered by the cremaster muscle.

FIG. 15. Halsted 1903, Plate 2. The first row of fine silk sutures pulling the cremaster and its fascia up under the internal oblique muscle has been tied. The second row of sutures, catgut, which will hold the internal oblique muscle and the conjoint tendon to Poupart's ligament, have been placed.

FIG. 16. Halsted 1903, Plate 3. The first row of sutures has been covered. The second row has been tied, the only parts being visible are those which have pierced Poupart's ligament. The third row of sutures, which will pull the lower leaf of the aponeurosis of the external oblique muscle up under the upper leaf, has been laid.

FIG. 17. Halsted 1903, Plate 4. The third row of sutures has been tied, the fourth row of sutures have been placed, which when tied will complete the overlapping of the cut edges of the aponeurosis of the external oblique muscle. The skin is closed with a buried continuous silver suture, and the incision covered with five or six layers of silver foil.

"The two outermost of these deep mattress sutures pass through muscular tissues and the same tissues on both sides of the wound. They are the most important stitches, for the transplanted cord passes out between them. If placed too close together, the circulation of the cord might be imperiled, and if too far apart, the hernia might recur. They should, however, be near enough to each other to grip the cord. The precise point out to which the cord is transplanted depends upon the condition of the muscles at the internal abdominal ring. If in this situation they are thick, and firm, and present broad raw surfaces, the cord may be brought out here. But if the muscles are attenuated at this point, and present thin cut edges, the cord is transplanted further out.\*

The transplanted cord lies on the aponeurosis of the external oblique muscle and is covered by skin only. . . . Our patients are kept on their backs for 21 days."

FERGUSON,<sup>5</sup> 1899

Alexander Hugh Ferguson, Professor of surgery of the Chicago Post-Graduate Medical School, presented his collection of sixty-four cases representing his operation for the cure of inguinal hernia, in July, 1899.<sup>5</sup> Primary union occurred sixty-one times although he had used rubber gloves only six times (on three bilateral cases). This paper is profusely illustrated with eleven drawings, which show all the details of the operation. He has reduced the number of illustrations in his book<sup>6</sup> published eight years later in 1907. Ferguson says in this book on page 280: "Since the presentation of this operation (1899) to the profession the writer has not found it necessary to make any material improvements or modifications."

Through clinical work and dissections on cadavers Ferguson learned that many people had a more or less extensive defect

\*"Instead of the interrupted buried skin suture as shown in Plate 3, (Halsted, 1893), we now use an uninterrupted buried skin suture without knots, which is withdrawn after two or three weeks."

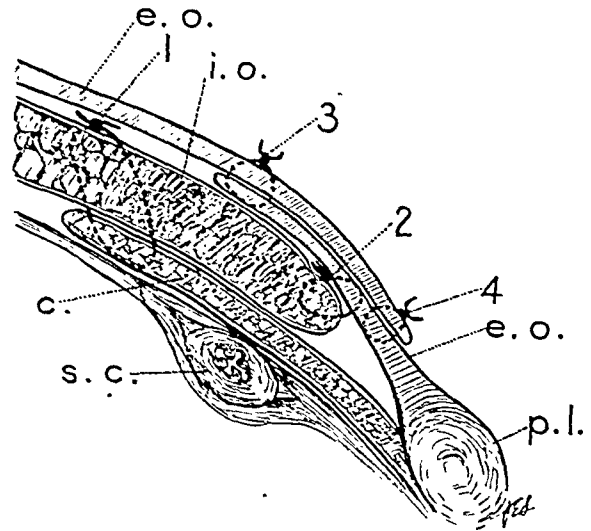


FIG. 18. Halsted 1903, Plate 5. A sagittal section through the abdominal wall after the Halsted herniorrhaphy of 1903, showing the overlapping of the layers of the abdominal wall and the spermatic cord in its natural position.

between the lower edge of the internal oblique muscle and Poupart's ligament. "The first important observation I made was that the return hernial protrusion began at the upper and outer portion of the seat of operation above the cord, and usually near Poupart's ligament. To my astonishment, I found an angle between the lower border of the internal abdominal oblique muscle and inner aspect of Poupart's ligament wholly unprotected by the internal oblique and transversalis muscles."

The operation is divided into four steps:

1. In his original paper<sup>5</sup> he uses only the strongly, upwardly curved incision, the "semilunar skin incision," but in his book<sup>6</sup> he says, "or straight," skin incision. He preferred the highly curved incision because of the greater exposure. "Take a pledget of gauze and with it turn the flap of the skin, subjacent fat and fascia downward and outward over the thigh."

2. He exposes the contents of the inguinal canal by cutting through the aponeurosis of the external oblique muscle, "far beyond the internal ring."

3. The hernia sac is opened, investigated and any excess omentum is suture-ligated and removed. The sac is ligated or sutured or, "an internal purse string thrown around it. The transplantation of the stump of the sac high up underneath of the deep muscles, or

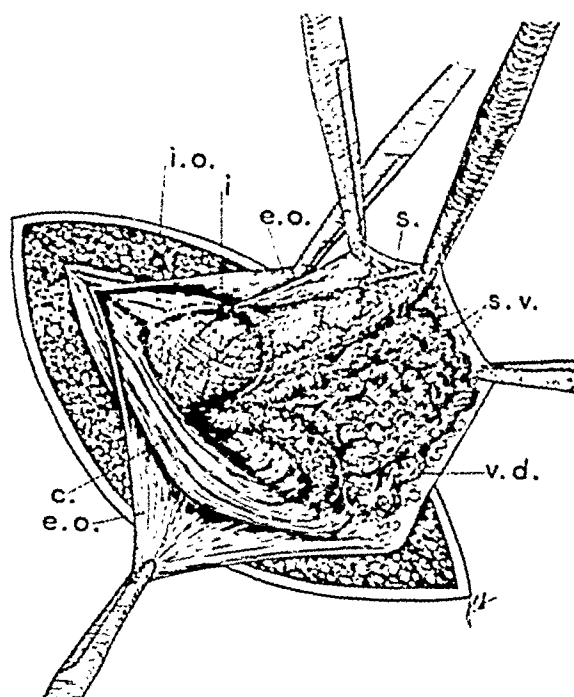


FIG. 19. Halsted 1903, Plate 6. "The vas deferens should not be raised from its bed or handled or even touched, lest thrombosis of its veins occur." In a foot note Halsted says; "The fact is that the vas deferens is frequently accidentally handled or squeezed, but harm that we know of has never resulted since we have recognized the necessity for exercising great care in the separation and ligation of the veins." Here the hernia sac and spermatic veins, s.v., are picked up without manipulating the vas deferens, v. d. Intestine, i., is shown in the sac.

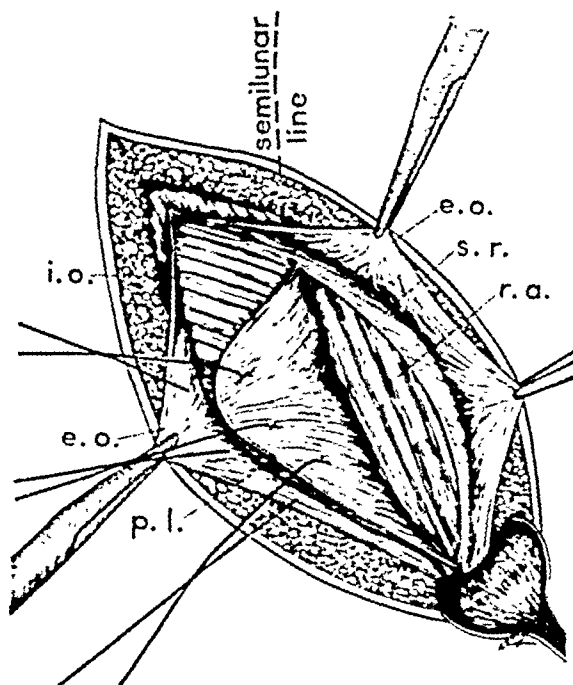


FIG. 20. Halsted 1903, Plate 7. "Four years ago the author used, for the first time, a part of the aponeurosis covering the right rectus muscle to close the lower part of the right inguinal canal. I felt compelled in this case to resort to some such measure, for the internal oblique was fatty and attenuated to a degree not very often seen by us, and the rectus muscle did not seem to promise so much as its fascia did. This patient was a college-mate of mine and for this reason I wished, perhaps, more than ever, to be very sure of the result. One year ago I examined this patient very carefully and was gratified to find as solid a closure as one could desire." r. a., rectus abdominis muscle; s. r. sheath of the rectus muscle.

twisting it and suturing it at the internal ring has nothing special to recommend it. . . . The cord is not disturbed. . . . Tearing the cord out of its bed is without any anatomic reason to recommend it. . . . Let the cord alone, especially the vas deferens, for it is the sacred highway along which travel the vital elements indispensable to the perpetuity of our race. . . .

"The veins of the cord should not be disturbed. If a varicocele complicates the hernia, deal with it in the usual way.

"The cremaster muscle is allowed to hug the cord and is reattached to the internal oblique muscle, for in this, its normal position, it is afforded an opportunity to resume its double function of (a) holding down the muscle from which it originally received its muscular fibers, and (b) by its contraction aid in emptying out the

valveless veins, in the cord. No part of the muscle should be removed, but its redundancy is taken up with the suturing of the transversalis fascia and internal oblique.

"An abnormal quantity of subserous adipose tissue is sometimes deposited around the sac and cord and along Poupart's ligament. This is an etiologic factor in hernia, and if not removed tends to cause a return of the hernia."

The transversalis fascia, which forms the internal inguinal ring, being stretched by the hernia, is sutured up with a separate suture or with the suture used to sew the internal oblique muscle to Poupart's ligament.

4. The internal oblique and transversalis muscles are sutured to Poupart's ligament. "Take care not to split Poupart's ligament by grasping the same longitudinal fibers with the needle each time."

5. Ferguson uses Bloodgood's operation<sup>7</sup> when he deals with a case having a weak conjoined tendon. In Bloodgood's own words: "In my method the sheath of the rectus is divided posteriorly and the belly of the muscle is brought out behind the internal oblique." The rectus abdominis muscle itself is sewed to Poupart's ligament. Concerning this procedure Halsted<sup>8</sup> wrote: "The transplantation of the rectus muscle recommended by Bloodgood to close this defect (insufficient conjoined tendon) seems to accomplish what its originator hoped it might, although, a priori, one would fear that this powerful straight muscle must eventually draw away from Poupart's ligament to which it had been sewed."

The aponeurosis of the external oblique muscle are sewed together in lateral folds or by overlapping. The patient is kept in bed for three weeks. No. 1 chromic catgut is used to tie off the sac Nos. 00 and 0 chromic catgut for all other sutures.

Ferguson believes that, "The key to the radical cure of oblique inguinal hernia is to suture the internal oblique muscle and its tendon to the inner aspect of Poupart's ligament, as low down as possible, without undue tension, after having ablated the sac and strengthened the internal ring with a few stitches above the root of the cord. Any operation for cure of hernia that diverts the cord from its natural course favors return, endangers the testicle and is empirical."

HALSTED,<sup>8</sup> 1903.

In his paper of 1903,<sup>8</sup> Halsted describes his new operation for inguinal hernia. This operation represented a great deal more experience than that described in 1893: "The present operation has been evolved by degrees and stands for the experience of 14 years derived from more than 1,000 operations for the cure of inguinal hernia."

Previously he had stressed excision of the veins of the cord and transplantation of the cord. But now, "The success attending excision of the veins (118 cases without recurrence at the site of the transplanted vas deferens) seemed to justify a continuance of this practice, provided it occasioned no undesirable results; but excision of the veins with transplantation of the vas deferens taught us that, not infrequently, a hydrocele, usually insignificant in size, was to be expected, and that in about 10% of the cases atrophy of the testicle had occurred."

A new feature of this operation of 1903 is the use of the cremaster muscle: "A device which we hit upon in our efforts to close more securely the lower part of the canal, but which we now make use of as often as feasible, probably in over 75% of the cases, is the utilization of at least a part of the cremaster muscle, which we formerly cut away."

Halsted describes his new operation:

"1. The aponeurosis of the external oblique muscle is divided and the two flaps reflected as in the Bassini-Halsted operation.

"2. The cremaster muscle and fascia is split, not directly over the centre of the cord, but a little above it.

"3. The internal oblique muscle is made as free as possible. A little artefaction is here often necessary. If the muscle cannot be drawn, without tension, well down to Poupart's ligament, it helps, I think, to make a relaxation cut or two in the anterior sheath of the rectus muscle under the aponeurosis of the external oblique muscle. This sheath being in part the aponeurosis of the internal oblique muscle, one can readily comprehend that incisions into it, if properly made, might be of service. It is well, however, to postpone making such incisions until the sewing of the internal oblique muscle to Poupart's ligament is begun, for then the amount of tension can be nicely gauged and the number, length and precise position of the relaxation cuts determined. A second reason for postponing

the relaxation incisions into the anterior sheath of the rectus muscle is that we sometimes use this portion of the rectus sheath to close the lower part of the inguinal canal.

"4. When the veins are large, and this is usually the case, they should be excised with very great care to avoid even the slightest extravasation of blood into the tissues about the smaller veins and about the vas deferens which they accompany. And the vas deferens, as first emphasized by Bloodgood, should not be raised from its bed or handled or even touched, lest thrombosis of its veins occur. (The fact is that the vas deferens is frequently accidentally handled or squeezed, but harm that we know of has never resulted since we have recognized the necessity for exercising great care in the separation and ligation of veins.) (Halsted 1903 Plate 6.) The veins should be ligated as high up in the abdomen as possible, being pulled down quite firmly just before the ligature (in a needle with the blunt end first) is passed between them. As a precaution against slipping, we apply two ligatures of fine silk, both for the abdominal stump and for the testicle stump of the veins. The farther from the testicle the veins are divided, the better, provided, of course, that their stump is external to the external abdominal ring.

"5. Ligation of the sac by transfixion or by purse string suture at the highest possible point. Both ends of this suture, after tying, are threaded on long curved needles, then carried far out under the internal oblique muscle from behind forwards, and, passing through this muscle, about 5 mm. apart, are tied.

"6. The lower flap of the cremaster muscle and its fascia is drawn up under the mobilized internal oblique muscle and held in this position by very fine silk stitches, which having engaged firmly a few bundles of the cremaster, perforate the internal oblique, preferably where it is becoming aponeurotic, and are tied on the

external surface of the latter; (Halsted 1903 Plate 1).

"7. The internal oblique muscle, mobilized, and possibly further released by incising the anterior sheath of the rectus muscle, is stitched (the conjoined tendon also) to Poupart's ligament in the Bassini-Halsted manner. (Halsted, 1903 Plate 2.)

"8. The aponeurosis of the external oblique muscle is overlapped, as shown in Halsted 1903, Plates 3 and 4. This is known as Andrew's method, although devised independently by us.

"9. The skin is closed with a buried continuous silver suture, and the incision covered with five or six layers of silver foil. It is unnecessary to dress or examine a wound closed in this manner for two weeks, when the wire may be withdrawn. Patients are kept in bed from eighteen to twenty-one days."

#### SUMMARY

Eduard Bassini's paper describing his new operation for inguinal hernia was dated July 30, 1889 but did not appear until 1890. He had operated, upon 251 patients over a four and one-half year period with six recurrences. The main features of his operation are: suture of the threefold layer to Poupart's ligament to form the posterior wall of the new inguinal canal; suture of the aponeurosis of the external oblique muscle over the cord, forming the anterior wall of the new inguinal canal.

Wm. S. Halsted's new operation for inguinal hernia was described December, 1889. He presented five patients, representing work over a six-month period. The main features of this operation are: excision of most of the veins of the spermatic cord; transplantation of the vas deferens under the skin; closure of the structures of the abdominal wall (excluding the peritoneum and the skin) in one layer with interrupted mattress sutures.

Alexander Hugh Ferguson's inguinal herniorrhaphy, having been performed by him sixty-four times, was described July 1,

1899. In his book in 1907, he still recommended the same operation. The main features of the Ferguson herniorrhaphy are: leaving the cord undisturbed; utilizing the cremaster muscle and the transversalis fascia in the repair, and suturing the internal oblique muscle and the conjoined tendon over the spermatic cord to Poupert's ligament, it being recommended that the spermatic cord not be lifted from its natural bed.

Wm. S. Halsted published his new method of hernia repair August, 1903. The main features of this operation, as contrasted with the Halsted of 1893, are: transplantation of the neck of the sac, careful excision of any enlarged veins of the spermatic cord, utilization of the cremaster muscle and the transversalis fascia in the repair, and placing three rows of interrupted silk sutures and one of catgut in an overlapping type of repair of the layers of the region. Concerning this

operation, Ferguson<sup>6</sup> wrote in his book: "This modification, which is very similar to my operation, was not published until three years after I produced my method."

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# TRACTION LOOP

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THE removal of skin sutures is and always has been a tormenting mental hazard for most patients. Only too frequently the impending procedure is dis-

practiced by others. At any rate, I have never seen it used routinely and present it for the benefit of those to whom it may appeal.

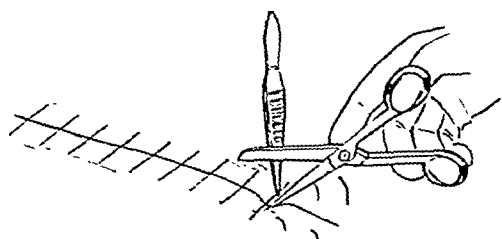


FIG. 1. Usual, more painful method of cutting sutures.

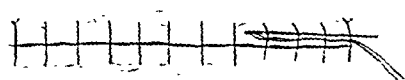


FIG. 2. Threading "traction loop" through completed suture line.

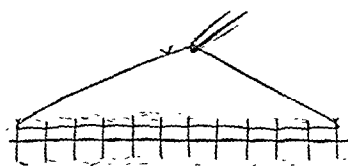


FIG. 3. "Traction loop" completed.

cussed with other patients or friends, who have themselves been the subject of this experience, until a build-up is established far beyond the importance of the occasion. Then, too, a hospital atmosphere following surgery leads to an apprehensive attitude which magnifies the real significance of this relatively simple procedure. More frequently than not the patient makes every effort to school himself or herself against the inevitable suture removing day.

To lessen the pain of suture removal it occurred to me some time ago to employ the introduction into the suture line of a "traction loop" to facilitate the elevation of the stitch at the time of removal. This is such a simple device that it may have been

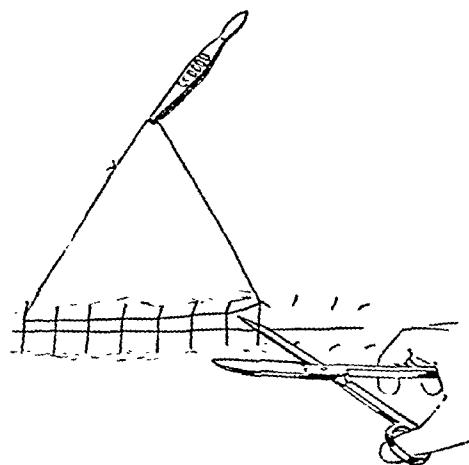


FIG. 4. Cutting sutures with the help of the "traction loop."

It is my custom to suture the skin with a running modified mattress suture. At the completion of the skin suture, I simply run a continuous loop of silk thread (or cotton) through each individual suture. This is done by reversing the needle so that the non-cutting end (threaded end) will pass under each suture without cutting the thread. The traction thread having been passed under the entire suture line is then tied forming a loop. This "traction loop" hangs, as it were, from the suture line.

When the sutures are to be removed, the "traction loop" is elevated with a pair of forceps. This pulls the sutures away from the skin surface, one at a time as they are cut. With the scissors paralleling the skin surface the individual sutures are cut one after another until the "traction loop" is released. With all sutures cut, there re-

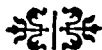
mains the simple process of pulling each out of the skin. The whole process is simple, quick and relatively free of pain.

The "traction loop" eliminates the usual tissue forcep searching, digging for and elevating each individual suture which frequently is embedded or buried in dried serum or coagulated blood. Also, as the "traction loop" is inserted at the time of operation before swelling has developed,

every stitch is included which is an insurance against missing a stitch at the time of removal.

Practical results have been so encouraging that it has amply repaid me to add this simple pain-saving device to my routine technic of wound closure.

I am indebted to Mrs. Robert C. Hunt for illustrating the technic used in employing the "traction loop."



IN the large gaping wound of the soft tissue of the face, one may be tempted to try closure early by suture. This should never be done before at least temporary fixation of bone fragments, otherwise collapse of the latter will occur, with great deformity and interference with function.

From "War Medicine — A Symposium" edited by Winfield Scott Pugh (Philosophical Library, Inc.).

# MISUSE OF ADRENALIN AND CORAMINE

## ALTERED DRUG EFFECTS DURING ANESTHESIA

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GENERAL anesthesia alters the effects of certain drugs. Indeed, the pharmacologic effects of many drugs may vary so markedly when administered during anesthesia that current physiological and pharmacological reports find it necessary to specify the type of anesthetic agent and anesthetic technic employed. Clinically, there seems to be insufficient appreciation of this fact. Untoward reactions, frequently fatal, have been known to be produced during general anesthesia by the use of certain drugs which are known to be therapeutically efficient in the unanesthetized state. Thus, whereas pitressin or prostigmin have been recommended to prevent intestinal distention,<sup>1</sup> their administration during certain types of general anesthesia may produce bronchial constriction or coronary constriction.<sup>2</sup>

As regards resuscitative drug therapy during general anesthesia, it has been pointed out that adrenalin and coramine have been gravely misused.<sup>3</sup> Their efficacy in the unanesthetized subject is not contested, but in the anesthetized subject they may become detrimental. The cardiac conducting mechanism becomes sensitized during general anesthesia; and with certain agents, particularly chloroform and cyclopropane, this sensitization is so great that sub-therapeutic doses of adrenalin injected into the circulation may cause death following the production of ventricular fibrillation.<sup>4,5</sup> Adrenalin injected into the heart during anesthesia in cases of cardiovascular collapse has proved to be fatal in every report encountered by the author.

Adrenalin used locally in the operative field to aid hemostasis because of its vasoconstrictor action is another serious

misuse of the drug during general anesthesia. Case reports demonstrating this detrimental effect abound in medical literature. Guedel<sup>6</sup> cites two illustrative cases in his monograph on "Inhalation Anesthesia." In one, "the nares were packed with gauze saturated with 1-1000 adrenalin before the drop ether anesthesia was started. Four or five minutes after the induction the patient suddenly became restless, took two or three deep breaths and died." The other case was that of "a thirty-two-year-old woman having a frontal sinus operation under ether anesthesia. With the anterior sinus wall removed, the bleeding was obscuring the field, and the surgeon was sloshing 1-1000 adrenalin into the sinus to control the bleeding. It was fairly effective but a lot of sloshing was required. About half an ounce of adrenalin was used before the patient suddenly died."

In one issue of *Anesthesiology* appear two case reports on the misapplication of adrenalin during general anesthesia. In one case,<sup>7</sup> severe cardiovascular derangements occurred during a Caldwell-Luc operation under nitrous oxide-ether anesthesia when a pack soaked with adrenalin 1-1000 solution was placed over the bleeding area. In the other case,<sup>8</sup> sudden death resulted during cyclopropane-ether anesthesia following the injection of 2 cc. adrenalin (1-1000 solution) into the four quadrants of the cervix to produce an avascular operating field.

Coramine also shows varied effects depending upon whether it is used in the unanesthetized or anesthetized subject. In the subject anesthetized with a barbituric acid derivative, it has been shown experimentally<sup>9</sup> that the administration

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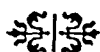
of coramine will aggravate rather than diminish respiratory and circulatory depression. The same untoward effect may occur clinically and was, in fact, observed during a study of clinical experiences with various analeptics.<sup>20</sup>

To reduce cardiac irritability during anesthesia, the use of intravenous procaine has been recommended.<sup>11</sup> Here, too, it is important to remember that there is a contrasting difference in the effects produced by intravenous procaine depending upon whether the subject is anesthetized with a general anesthetic agent or is unanesthetized. The injection into the general circulation of procaine, or another local anesthetic agent, is dreaded and carefully avoided in the conscious patient in whom it may produce central nervous stimulation characterized by generalized convulsions. When such a complication occurs, it can be alleviated by the administration of general anesthesia, particularly rapid-acting anesthetic agents such as intravenous pentothal sodium or chloroform inhalation.<sup>12</sup> During general anesthesia, which entails some depression of the central nervous system, the intravenous injection of procaine is less apt to produce central nervous system stimulating effects. Its influence on reducing cardiac irritability can then be employed advantageously as has been demonstrated during certain intrathoracic procedures.<sup>13</sup> During this latter type of surgery, particularly cardiac surgery, it has been suggested that procaine can be administered prophylactically in a concentration of .1 of 1 per cent in the intravenous drip.<sup>14</sup>

In conclusion, it is re-emphasized that the administration of coramine, adrenalin or other sympathomimetic amine during general anesthesia is not warranted because such administrations have repeatedly been shown to be detrimental. The intracardiac injection of adrenalin in a patient during general anesthesia should be avoided. Resuscitative measures are best confined to artificial respiration with oxygen through an endotracheal tube connected to a breathing bag with carbon dioxide absorption. The resulting bellows action on the lungs by rhythmic, graded manual pressure on the breathing bag is also beneficial as a form of cardiac massage. Manual cardiac massage is a definite worth while procedure to be used wherever applicable. The use of intravenous procaine, instead of adrenalin, is suggested in cases of cardiovascular dysfunction due to cardiac hyper-irritability.

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# Case Reports

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## DISCREPANCIES IN PAIN AND SYMPTOM DISTRIBUTION.

### POSITION OF THE TESTICLES AS A DIAGNOSTIC SIGN IN SITUS INVERSUS TOTALIS

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IN the various discussions on cases of situs inversus one of the most controversial yet important aspects on this subject, namely, the advent of disease in these organs, has received comparatively little attention. The position of the testicles in these individuals, as a diagnostic sign, is hereby emphasized.

The location of pain and accompanying signs of disease in the viscera of cases of situs inversus have been most variable according to reports in the literature.

#### REVIEW OF LITERATURE

DePol,<sup>1</sup> in 1933, was first to report the apparent discrepancy between the localization of signs and symptoms and the true position of the diseased organs. In only 50 per cent of the forty-six recorded case reports of appendicitis with situs inversus, according to the author, signs and symptoms were present on the right side of the abdomen. DePol personally recorded a case of transposed viscera, in which the patient had symptoms of acute appendicitis on the left side.

Similar reports of left-sided pain were recorded by Votta and Robertson<sup>2</sup> and Lucenti.<sup>3</sup> Hemple<sup>4</sup> reported a case of unsuspected transposition with typical right-sided signs of acute appendicitis. At operation, the appendix was found in the left lower quadrant. Further examination revealed complete situs inversus.

A similar case was reported by Block and Michael.<sup>5</sup> King<sup>6</sup> described the case of a

woman who was treated at the Johns Hopkins Medical Dispensary, at which time complete transposition of the viscera was discovered. Two years later she was admitted to the surgical ward of the hospital with severe right lower quadrant pain. Examination revealed a distended abdomen with maximal and rebound tenderness in the right lower quadrant. Rectal examination was normal. Since the patient was known to have situs inversus, a mid-line incision was made. The appendix was found far to the left of the mid-line acutely inflamed. In all, over sixty patients have been reported in the literature with variable localized findings prior to appendectomy for the transposed appendix.

Wood and Blalock<sup>7</sup> in 1940, reviewed the literature for reports on transposed diseased gallbladders and found seventeen patients with this condition. Pain was most severe in the left upper quadrant in eleven, whereas in two it was most severe in the right upper quadrant. In the remaining three patients the pain was most notable in the epigastrium.

#### THEORY OF DISCREPANCY

In discussing this discrepancy of localization of symptoms, King first questions the theory of parietal peritoneal irritation, as demonstrated by Jones.<sup>8</sup>

Jones experimentally distended various levels of the gastrointestinal tract with balloons, the distention usually causing localized pain and discomfort in the ab-

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dominal wall. Distention of the cecum, for example, almost uniformly caused discomfort at McBurney's point.

According to King, Jones' theory failed to explain the presence of exquisite tenderness at McBurney's point and yet at operation the inflamed appendix may be found in a retrocecal position, in the pelvis or high in the abdominal cavity. This position could not have irritated the peritoneum at McBurney's point. It also did not explain the discrepancy in the localization of pain in cases of appendicitis with situs inversus. Jones, in his monograph, states that one of his patients referred the pain caused by cecal distention to a place on the lower-left abdominal wall corresponding to a left McBurney's point. No explanation is offered for this unusual sign, nor is mention made whether the patient had situs inversus.

King advanced the theory that the peripheral nerve routes may or may not be transposed, independent of the viscera, the rotation occurring about 50 per cent of the time in cases of situs inversus. When peripheral nerve transposition does occur in these cases, both viscera and pain pattern are reversed.

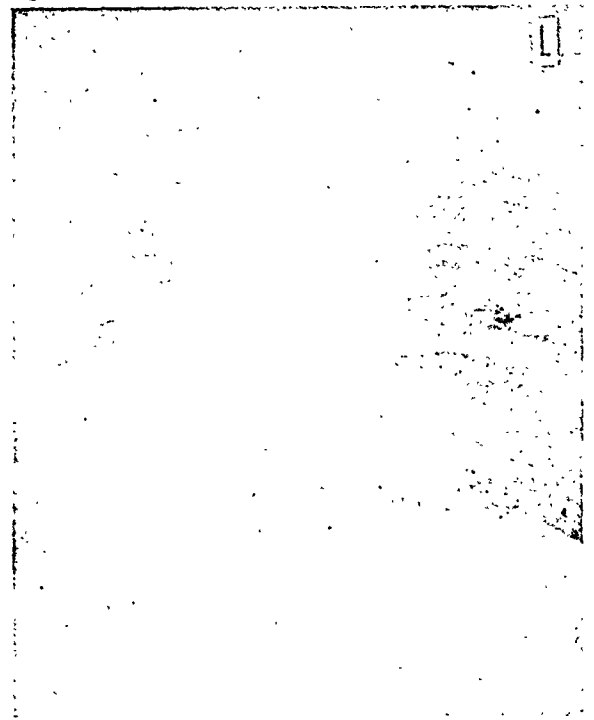


FIG. 1. Chest x-ray of Case 1.

However, in cases of non-rotation of the nerve pathways, the pain pattern remains in its usual location, although the viscera are on the contralateral side of the body.

It is important to note that there exists a discrepancy in the localization of abdominal pain as well as other symptoms. This should be considered in a case of



FIG. 2. Upper gastrointestinal series of Case 1.



FIG. 3. Barium enema of Case 1.



FIG. 4. Scrotal sac of Case II.

known situs inversus in which a pathological process develops.

#### CLINICAL CRITERIA

Examination of cases of situs inversus will reveal the following abnormal findings: cardiac dullness and apex beat on the right side; stomach tympany to the right of the epigastrium and liver dullness on the left.

#### POSITION OF TESTICLES

In males, a definite clinical sign can be found upon examination of the scrotum. The right testical will be found to descend lower than the left in these cases, whereas in individuals with normally situated organs, the left testicle usually hangs lower than the right. This enables the examiner quickly to appraise a male patient and rule out the possibility of transposition of the viscera when symptoms appear to be localized in a questionable region (i.e., symptoms of appendicitis in the left lower quadrant).

Examination of the scrotum for the position of the testicles in normal individuals, at a service discharge center, has revealed

the left testicle hanging lower than the right in 93 per cent of a total of 6,000 men. The specific explanation for this is not described in the literature.

According to Lowsley and Kerwin,<sup>9</sup> the testicles are situated in the scrotum, one on each side, the left gland being usually somewhat lower than the right. The right spermatic vein enters the vena cava directly while the left spermatic enters the left renal vein. These veins are provided with valves, the valve at the orifice of the left sometimes being absent. The usual incidence of varicocele on the left side, continue Lowsley and Kerwin, is due to these anatomical differences, which lend themselves to such a formation.

Thus it appears evident that the venous pressure is greater on the left side, and this probably is a factor in the usual presence of the lowered testicle on the left.

The presence of the lowered right testicle in individuals with situs inversus totalis, would therefore imply that complete rotation of the circulatory system takes place as well.

#### COMMENT

Although complete data are at present unobtainable, the increase in physical examinations due to the military emergency has revealed cases of situs inversus, who were completely unaware of their oddity because the condition in a healthy subject is essentially symptomless. The proper evaluation of symptoms, with the onset of disease in these cases is important, especially in combat areas.

#### CASE REPORTS

**CASE 1.** L. R., a seaman in the U. S. Coast Guard, was first seen as an out-patient at a station in Alaska. He complained of nausea, vomiting and pain in the left upper quadrant referred to the left shoulder.

Physical examination revealed dextrocardia on percussion, and the apex beat was found in the fifth right interspace in the anterior axillary line. Auscultation of the heart and lungs was normal. Liver dullness was percussed on the

left and the lower border was found parallel to the costal margin in the mammary line. There was marked localized tenderness in the region of the transposed gallbladder on the left. On standing upright, the right testicle was noted hanging one inch below the left in the scrotum. X-rays of the chest, an upper gastrointestinal series, and a barium enema confirmed the diagnosis of situs inversus totalis. (Figs. 1, 2 and 3.)

Stones were not visualized in the gallbladder on x-ray. The patient responded well to antispasmodics and a fat free diet without recurrence of symptoms.

CASE II. L. G., who was also a seaman in the U. S. Coast Guard. At the time of an annual physical examination, it was noted that the apex beat was palpated in the sixth right interspace, inside the right mammary line.

Examination revealed the same findings as noted in the previous case. A picture of the right testicle hanging lower than the left in the scrotum was taken. (Fig. 4.) Complete x-ray examinations confirmed the diagnosis of situs inversus totalis.

The patient's history as noted in his health record is significant. He had been at sea fifteen months previously, when he suffered an acute attack of right lower quadrant pain accompanied by rebound tenderness and spasm. He was taken off the ship and dispatched immediately to a hospital for an emergency appendectomy. At operation, a McBurney's incision was made in the right lower quadrant. A Weir's extension of the original incision was necessary in order to free the acutely inflamed appendix attached to the cecum deep in the left iliac region.

Inconsistencies in pain and symptom distribution as compared with the position of the diseased organ was proved in one of these cases and was a probability in the other individual. The position of the right testicle was lower than the left in the scrotum in both cases.

### SUMMARY\*

The development of pathological disorders in cases of situs inversus totalis can produce paradoxical pain distribution as compared with the position of an affected organ.

The presence of a right testicle lower than the left in the scrotum is described as a physical sign of situs inversus totalis.

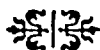
Two cases of situs inversus totalis and their findings are presented.

Grateful acknowledgement is made to Dr. O. S. Lowsley, Director, James Buchanan Brady Foundation, Professor Harry A. Charipper, Washington Square College, New York University, and Professor James B. Hamilton, Long Island College of Medicine, for helpful advice and suggestions.

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\* Since the completion of this article four other cases of known situs inversus totalis were seen by the author. All of these individuals manifested this testicular sign.





# INTESTINAL OBSTRUCTION DUE TO GALLSTONE\*

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**I**NTESTINAL obstruction by a gallstone is an infrequent occurrence. Walters and Snell<sup>1</sup> state that stones account for not more than 1 or 2 per cent of all obstructive lesions of the bowel. The relative incidence of this condition has also been corroborated by Jackson<sup>2</sup> who places the frequency between  $\frac{1}{2}$  and 2 per cent of cases of intestinal obstruction. Moore<sup>3</sup> has reviewed the literature prior to 1925 and his reports also show that between 1 and 2 per cent of all intestinal obstructions are the result of gallstones. As Mayo and his collaborators<sup>4</sup> have pointed out, the cause of obstruction is usually not suspected before operation and a history of chronic cholecystitis is of no value.

A review of the experience of the Mayo clinic<sup>5</sup> with intestinal obstruction produced by gallstones, points out that there is nothing characteristic about this condition. In their report of only ten cases the correct preoperative diagnosis as to the cause of the obstruction was not made in any case. They further state that for a correct diagnosis the clinician must depend upon the surgeon or the postmortem findings.

Gallstone ileus occurs more frequently in females than in males in a ratio of about 3-1. Impaction of a stone in the cystic duct for any length of time leads to the following consequences: (1) ulceration of the ducts with pyrexia, or abscesses of the liver and bile ducts and resultant subacute pyemia; (2) perforation into the adjacent tissues; (3) inflammation and abscess of the gallbladder which may open externally, perforate into the peritoneum or ulcerate into the intestines; (4) formation of a fistula between the gallbladder and the duodenum. The very great majority of

gallstones which cause obstruction have passed through the latter fistulous communication.<sup>6</sup> Since the small intestine gradually narrows in calibre from the duodenojejunal angle to the ileocecal valve, a stone, therefore, escaping the duodenum will most probably travel onward to rest in the terminal portion of the ileum.

If a sure diagnosis of gallstone obstruction could be made, it is certain that the best results would be obtained by surgical intervention at the earliest possible moment, using the ordinary principles now governing the treatment of all forms of intestinal obstruction as advocated by Wangenstein.<sup>7</sup>

Foss and Summers<sup>8</sup> have reviewed the literature and observed that intestinal obstruction due to gallstones carried one of the highest mortalities among the various causes of acute bowel obstruction. This is also borne out by McNamara et al.<sup>9</sup> who reasoned that, although immediate surgery is indicated, failure to recognize the stone clinically as a possible cause of obstruction is probably reason for delay.

## CASE REPORT

Mrs. A. F., a native American, white female, aged sixty-nine, widowed with four children, weighing 160 pounds, was admitted to St. Elizabeth hospital by ambulance on August 6, 1945.

For two weeks prior to admittance, she was treated for a severe "cold," cough and lack of appetite. On August 5, 1945, she complained of severe abdominal pain, obstinate constipation and vomiting. An enema gave no relief and the following day, August 6th, she was taken to the hospital. On admission her temperature was 100°F., pulse 100, her face was flushed and she complained of abdominal pain.

\* From the Surgical Service, St. Elizabeth Hospital, Chicago, Ill.

Her father died at seventy years of liver trouble; her mother died of a stroke at seventy-one years; one sister died of diabetes; one brother had an accidental death, one died of heart disease and two died of carcinoma of the stomach; two sisters are living and well.

As a child she had had rickets. In the past few years a hypertrophic arthritis had produced a semi-invalid state. There was a history of repeated flatulence and eructation after meals as well as occasional mild distress in the upper right quadrant. She drank coffee moderately, enjoyed food and slept well. She had complained of frequent headaches, wore glasses and had an upper denture. She had a thyroidec-tomy performed in 1907. Her married life was uncomplicated.

Physical examination revealed a fairly well developed female who appeared acutely ill. Her skin was normal in color and her face was flushed. Her temperature was 100°F., pulse 120, respirations 28. The pupils were equal and reacted to light and accommodation. The sclera and conjunctiva were not injected or jaundiced. The ears, nose and throat were essentially normal. There was a scar over the thyroid area.

The chest presented coarse râles over the bronchial area and fine moist râles in both lower lung bases. Lung excursions were good and no apparent dullness was noted. There was considerable whitish expectoration. Respirations were somewhat rapid and slightly labored.

The heart borders were exaggerated to the right and left with the apex beat in the fifth interspace. A tachycardia was present with a marked accentuation of the first sound but no murmurs. Blood pressure was 160/90.

The abdomen was distended. There was generalized abdominal pain, at times intermittent and at times more severe in the upper and lower right quadrants. There was considerable flatulence and borborygmus. There were no palpable masses or dullness and no rigidity. The liver, kidney and spleen were not palpable. No scars or hernia were present. The legs showed moderate varicosities but no edema.

The reflexes were normal throughout. The spine and genitalia were normal. A bimanual vaginal examination revealed nothing of significance and a rectal examination revealed no tumor or palpable mass but some small external hemorrhoids.

An x-ray examination of the chest on August 6, 1945, revealed "definite congestion and infiltration of the right base, which could be due to a bronchopneumonia and a small amount of pleural exudate in the right costophrenic angle. The lung fields are otherwise normal. There is an arteriosclerotic aorta. The heart is not enlarged."

On August 8, 1945, a flat film of the abdomen showed "abnormally distended loops of small intestines, indicative of a partial ileus."

On August 11, 1945, a flat film of the abdomen showed a "very marked abnormal distention of multiple loops of small intestines, indicative of a marked ileus."

On August 6, 1945, the erythrocyte count was 4,470,000, the leucocytes 22,650 with 88 per cent polymorphonuclears; the hemoglobin was 85.6 per cent.

The urine was essentially negative. The blood was type O and the Wassermann test was negative.

The diagnosis was intestinal obstruction.

The therapy before surgery was as follows: 12,000 cc. of normal saline with 5 per cent glucose and insulin from August 6, to 13, 1945; morphine sulfate gr.  $\frac{1}{4}$  for pain; phenobarbital gr.  $1\frac{1}{2}$  for restlessness; enemas plain, soap suds and turpentine daily; prostigmin 1 ampoule (1-4000); eserine gr.  $\frac{1}{100}$ ; surgical pituitrin 1 ampoule given with each enema and high colonic flushing; Wangenstein suction continuously.

On August 13, 1945, the abdomen was opened through a lower mid-line incision. A hard mass was palpated in the ileum. Beyond the mass the bowel was collapsed, while above the site of impaction the intestine was distended and grossly thickened. The surrounding lymph vessels were dilated. The mass could not be moved either up or down. A large single stone 3.3 cm. long, was removed through a longitudinal incision of the ileum. The intestine was closed transversely, using a Connell suture of intestinal catgut and a serosal layer of Lembert sutures. Sulfadiazine was powdered about the site and the abdomen was closed with drainage.

The postoperative therapy consisted of 5,000 cc. of normal saline with 5 per cent glucose and insulin; four transfusions of compatible citrated whole blood; prostigmin sulfate gr.  $\frac{1}{150}$ ; digifoline 1 ampoule every three hours; carbon dioxide-oxygen inhalations daily;

sodium sulfathiazole 7.5 Gm. intravenously; penicillin 2,000,000 units.

The first three postoperative days were very stormy due to shock. This was combatted by supportive treatment consisting of coramine, adrenal cortex extract, oxygen, whole blood, fluids and maintenance of body heat.

On August 15, 1945, the third postoperative day, drainage became apparent from the wound, in varying degrees from green to brown in color with undigested food particles in small and large amounts. Vaseline and aluminum powder were placed around the wound to prevent excoriation and digestion of the skin.

This fistula drained for three weeks. On September 8, 1945, the abdomen was reopened and the fistula was dissected. Due to the friability of the tissue, the bowel was broken into twice. In order to connect the small bowel in healthy tissue, two sections of jejunum were removed, at one place 5 cm. and at another 10 cm. At both these places an end-to-end anastomosis was made. Sulfadiazine was powdered into the wound and the abdomen closed without drainage.

The postoperative therapy after this second operation was as follows: three 500 cc. whole blood transfusions; three 1,000 cc. of amino acids intravenously; 500 mg. of vitamin C daily for four days; 6,000 cc. of normal saline with 2,000 cc. of 5 per cent glucose and insulin intravenously; carbon dioxide-oxygen inhalations daily for three days; Wangenstein suction for four days; morphine and digifoline daily for four days; deep breathing was encouraged and movements allowed. After the tenth day the patient was allowed to be up and about and on a general diet. She was discharged from the hospital on October 27, 1945, after sixty-two hospital days.

#### COMMENT

The high mortality caused by a gallstone producing a mechanical intestinal obstruction

is reason for early surgical intervention. Due to experience obtained from this case and in reviewing the literature, we deem it most important that early operation be advised, especially if, after twelve hours with the use of decompression, there has been no relief of the obstruction.

Another important consideration in the surgical approach of these cases is the fact that a stone impacted in the small bowel causes considerable edema to the bowel. The suturing of this type of bowel is very difficult and will not heal by primary union. In our opinion it would be better to exteriorize the bowel, then remove the stone and a little later, when the edema has subsided, to close the bowel and return it to the abdominal cavity. This may not necessitate a subsequent resection.

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# PAROXYSMAL HYPERTENSION DUE TO PARAGANGLIOMA

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**T**UMORS of the adrenal or sympathetic system causing the syndrome of paroxysmal hypertension represent an interesting group of cases from a diagnostic, symptomatic and therapeutic standpoint.

There is some evidence that the production of adrenalin is limited to the comparatively benign forms of this tumor; consequently the diagnosis of malignant atypical forms must rely not on the clinical symptoms but on the histological features.

Belt and Powell have collected sixty cases of medullary adrenal tumors. They revealed a remarkable series of symptoms of disturbance of the sympathetic system due to excessive production of adrenalin by the tumor. These include hypertension, glycosuria, tachycardia, vasomotor pallor and flushing, headaches, nausea, vomiting, great susceptibility to surgical shock with dyspnea, suffocation and pulmonary edema. In a number of cases the removal of the tumor was followed by recovery.

The tumors occurred chiefly in the adrenal, but also in retroperitoneal tissues, about the adrenal, in the kidney, about the pancreas and elsewhere. For the adrenal growths, they suggest the term, "pheochromocytoma," reserving "paraganglioma" for the chromaffin tumors of other regions.

Paraganglioma, a name applied to the group consisting of chromaffin types of cells, may occur where chromaffin cells exist. The structure presents small groups or a diffuse growth of round, oval, spindle, or polygonal cells, most of which are small. Giant cells with single or multiple nuclei also occur. The pigment is irregular in distribution, but gives the morphology and many special staining reactions devised for chromaffin substance. Homogeneous acidophile cells approached the type of sym-

pathetic ganglion cells. The stroma is composed chiefly of capillaries. These tumors were first described by Rabin in 1892. Since then about thirty cases of this type have appeared in the literature. They are accompanied infrequently by intermittent paroxysmal hypertension. Rountree reported a case in which the surgical removal of the tumor was followed by immediate recovery. The patient, a three-year old female, was admitted complaining of "peculiar spells." The paroxysmal attacks had commenced one and one-half years previously and were increasing in frequency and severity, occurring once or twice daily and lasting from one-half to four hours each. The "spells" were preceded by discomfort in the epigastrium, followed by dyspnea, occipital headaches, tachycardia, palpitation, vomiting and peculiar blanching of the skin. Observation in an attack revealed hypertension, a systolic blood pressure of over 300 mm. of mercury with normal blood pressure between. The tumor, on removal, proved to be a paraganglioma.

In the patient operated upon by Shipley, epinephrine was found in the tumor by Schultz.

Although the hypertension accompanying paragangliomas is usually intermittent in type, it may become continuous. Intermittent hypertension has also been observed in association with cortical tumors accompanied by clinical manifestations of hirsutism and virilism (Oppenheimer and Fishberg). In one case, autopsy revealed a tumor involving both the adrenal cortex and the medulla. The removal of such a tumor by Murray and Simpson, resulted in complete relief both from virilism and from hypertension, the systolic blood pres-

sure dropping from 200 to 120 mm. of mercury.

The treatment of these tumors is surgical. The use of cortical hormone and of sodium chloride decreases the surgical risk. Operations for hypertension require careful examination of kidneys, suprarenals and paravertebral areas to exclude unilateral kidney disease, suprarenal tumors or paragangliomas.

In the reported cases the sex was about equally divided. The age in the series varied from sixteen to sixty-nine. The average was 32.3 years.

The general health was usually good. Nervousness, anxiety, hemiplegia and dyspnea are frequent. The general appearance was normal between attacks. With the attacks, a worried, anxious, painful facial expression was noted. The fundi of the patients in older age groups, i. e., over thirty-five years, have definite retinal changes as minute hemorrhages, recent and remote, tortuous retinal arteries and edema. There is no direct correlation between the retinal changes and duration of symptoms, nor could the retinal changes be correlated with the height to which the blood pressure rose during attacks. One does find, however, that in all patients with retinal changes there was persistent hypertension, i. e., even between paroxysmal episodes the resting blood pressure was above the levels which are generally considered to be normal.

The heart showed the aortic and second pylmonic sounds are frequently accentuated. The degree of cardiac hypertrophy, dilation or decompensation varies with the degree and duration of the disease. Persistent tachycardia is frequent. The pulse may rise to 100 to 130 on the slightest provocation.

The resting blood pressure varies from perfectly normal to quite markedly elevated systolic and diastolic levels. It has been suggested that in the early stages the blood pressure will always be found to be normal when the patient is not having a paroxysmal attack, but if the disease lasts long enough the pressure will eventually be

permanently elevated. This change, however, may take place very rapidly over a period of several months and need not necessarily occur in those patients who have had the syndrome the longest.

On abdominal palpation, a mass was palpated in about 40 per cent of cases reported. It has occasionally been mistaken for the spleen and autopsy has disclosed the tumor lying retroperitoneally in the upper quadrant, pushing the kidney downward. Pyelograms are very valuable in localizing the tumor mass.

The urine is normal between attacks, albuminuria and glycosuria is occasionally observed during or following attacks. However, this is usually indicative of an underlying disease, such as chronic nephritis, diabetes, etc.

The primary symptom is variable. Palpitation, nausea, pain or smothering sensation in chest, roaring and pounding in head are characteristic. Severe pain in some locality usually accompanies attack. Epigastric, cerebral or precordial pain are most common sites. Anginal pain is frequent. Nausea and vomiting are very common. Several patients with nausea but without vomiting have stated that they gained relief from their distress by inducing vomiting. Respiration is exaggerated and accelerated during attacks. Pulmonary edema may occur and occasional deaths have been reported attributable to this complication. Sweating, flushing, increased nervous pressure, tetany, convulsions, fever, dilation of pupils, roaring in ears and fainting occur frequently, but are not constant. Fatigue and prostration follow attacks, lasting for several minutes to a whole day. Glycosuria and albuminuria are commonly found during or immediately following attacks.

Surgery with complete removal of the lesion has given the only relief in the cases that survived operation. Many are completely relieved of attacks and symptoms. Shock is a serious complication following surgery and is frequently out of proportion to the procedure. Adrenalin, blood plasma,

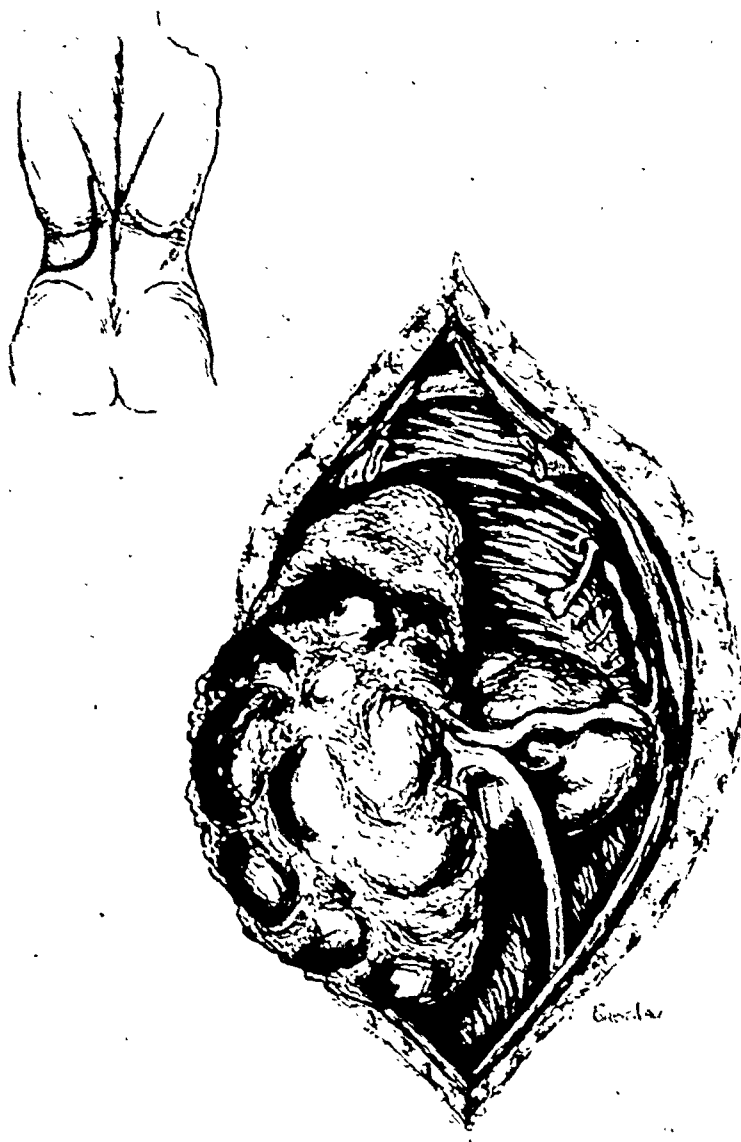


FIG. 1. The type of incision used is shown. The tumor was in the renal pedicle with the ureter coursing over it. The kidney is atrophic. The celiac ganglion and the first and second lumbar ganglia are demonstrated.

adrenal cortex, and whole blood are the chief remedies used in combating shock.

#### CASE REPORT

The patient was a colored female, age twenty-four. She was first seen on December 2, 1943. At that time she was complaining of fast pulse, throbbing headaches and weight loss. The liver was enlarged to the level of the umbilicus. The blood pressure was 190/100. Her usual weight was ninety-five pounds but at that time she weighed eighty-three pounds. Her basal metabolic rate was plus 35. There was an auricular fibrillation present so Lugol's solution was started and she was put on quinidine. Her blood pressure dropped to

130/70 in a few days; a marked anemia was present. The red blood cells numbered 2,210,000; the white blood cells numbered 14,300. The hemoglobin was 40 per cent. Smears were diagnostic of sickle cell anemia. She had a marked kyphosis. X-ray showed a marked wedging of the twelfth dorsal and first lumbar vertebrae. A flat K. U. B. failed to show any further abnormalities. She was given five transfusions of 500 cc. each. Her blood pressure reading was normal on occasion but tended to be elevated. The urine had shown albumin, grade 4, at the onset, but this had largely cleared up. An adrenal tumor was suspected. On January 4, 1944, a right subdiaphragmatic splanchnicectomy, partial celiac ganglioenc-

tomy, right first and second lumbar ganglionectomy with intervening trunks, was carried out. The right kidney and right adrenal were both normal. Following this her headaches completely subsided, but her blood pressure continued to run high. Three successive readings were: 184/100, 188/104, and 198/118. She felt good. Three more transfusions of 500 cc. each were given prior to exploration of the left side on February 7, 1944.

On February 7, 1944, a left nephrectomy and excision of paraganglioma, arising from the adrenal pedicle, was carried out, together with the excision of the greater splanchnic and the first and second lumbar sympathetic ganglia on the left. Excision was carried out through a left subdiaphragmatic approach, resecting the posterior portion of the twelfth rib to facilitate exposure, the patient being somewhat of a dwarf type of individual with a lower dorsal kyphosis. The operation was unusually difficult because of the kyphosis referred to. Upon exploring the kidney it was found to be atrophic. The renal pedicle was freed and exposing the tumorous mass further, it was found to be a degenerating tumorous mass which resembled very much a degenerating adenoma of the thyroid. The entire mass was removed along with the kidney, dissecting the mass from the vena cava and the aorta. The renal vessels were individually ligated. The tumor was in between the vessels. The ureter coursed over its surface. Upon its removal the blood pressure immediately fell to zero. The blood pressure at the beginning of the operation was 260/160. With transfusions and 50 per cent glucose the blood pressure gradually came up to 70/50. At the completion of the operation her general condition was fair. There had been no blood loss. Her blood pressure for the next two or three days ran around 80/40 to 80/50. She was in no apparent shock. During this time she was receiving adrenal cortex together with intravenous fluid. Her blood urea levels remained normal. About the fifth day her blood pressure was up to 120/70 and from then it gradually went back up until the day of her dismissal, her blood pressure having gone up to 180/110. For a few days there was some disturbance in her metabolism as evidenced by some edema of the lids which proved to be a nutritional and anemic edema. This was corrected by transfusion and correction of diet.

Her postoperative course was really very easy and uncomplicated. A complete description of the pathological report follows:

Gross: The specimen consists of a small infantile kidney, measuring 7.5 cm. by 3 cm. by 2.5 cm. The kidney capsule is somewhat thickened and strips with difficulty, revealing a finely granular, reddish-brown cortical surface. The cortex averages 3 mm. in thickness and contains numerous dilated and engorged glomeruli which are usually prominent. The cortical medullary demarcations are indistinct. The calices are not dilated and the epithelium lining the surface is intact. Near the origin of the ureter at the pelvis there is an irregular nodular, soft, reddish gray mass, measuring 4 cm. by 2.5 cm. by 2 cm. On section it is soft in consistency with almost complete central cystic degeneration. A second specimen consists of a flattened piece of fibro-fatty tissue, one portion of which contains an oval, bean-shaped mass.

Microscopic Section: Sections of the tumor mass found near the ureteropelvic junction show it to be composed of irregular, cord-like masses or groups of large polyhedral, occasionally spindle-shaped cells with fairly abundant cytoplasm and vesicular nuclei. The nucleoli are occasionally enlarged, but no mitotic figures can be seen. These cells are distributed in a stroma which is composed almost entirely of thin, delicate, papillaries that are frequently engorged with blood. In the cytoplasm small granules of brown pigment can be seen.

Sections of the kidney show extensive atrophy of the cortex and medulla with hyalinization of the glomeruli, large scar formation, and cystic degeneration. The blood vessels are thick-walled with thickening being due to intimal proliferation or hyperplasia of the media. In the tubules there are numerous albumin casts.

The third section of the flattened, bean-shaped mass of tissue shows it to be composed of typical nerve cells and fibers of the sympathetic ganglion.

Diagnosis: Paraganglioma; atrophic kidney; sympathetic ganglion.

She was dismissed from the hospital on February 17, 1944, and her course to January, 1946, has been good. Her blood pressure at this time is 170/100. She looks and feels well. Transfusions are required at intervals to combat the sickle cell anemia. In all, she has had

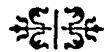
twenty-nine transfusions. Her cardiac status and renal status at the present are normal.

#### SUMMARY

The most prominent feature of this syndrome is sudden dramatic episodes of paroxysmal hypertension which are believed to be due to the outpouring of large amounts of adrenalin into the systemic circulation by these tumors. Attacks vary widely in duration from a few minutes to many days.

Intermittent attacks of hypertension, developing without apparent cause, accompanied by vertigo, nausea and vomiting, headaches, palpitation, dyspnea, and pain of anginal type may be considered characteristic of this syndrome.

A case of the chromafin cell type associated with paroxysmal episodes of hypertension is reported. The case was further complicated by marked sickle cell type of anemia which has required repeated transfusions to combat it.



MANY conservative operations on the blood vessels have been marred by functional failure, a physiological fault rather than an operative imperfection. This is due to thrombus formation occurring on the damaged intima and spreading peripherally to affect the collateral vessels.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams & Wilkins Company).



# DILATATION OF STOMACH

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**A**CUTE dilatation of the stomach is not a frequent autopsy finding. Occurring most often following an operative procedure in the abdomen, it has also been reported in a variety of other conditions including wasting diseases, various injuries and fractures, childbirth, overeating, and in association with spinal deformities. Because of its comparative rarity the condition is not well known and its relationship to sudden death not sufficiently emphasized.

We have recently seen a case that presented several unusual features:

## CASE REPORT

The patient, age twenty-six years, colored, a private in the army, was admitted from another military hospital with the diagnosis of: (1) ileitis, chronic, terminal, severe; (2) ileostomy and colostomy for treatment of ileitis performed August 22, 1945; and (3) severe malnutrition.

His family history revealed nothing pertinent. He had had no serious illnesses. The patient had been a laborer previous to induction and had twenty months of tropical service.

In March, 1945, the patient, while in the Southwest Pacific, developed gastrointestinal symptoms including lower abdominal, cramp-like pains and vomiting. His symptoms became worse; he lost 20 pounds, but bowel habits remained normal. On August 4, 1945, the symptoms became more acute. He was then admitted to a station hospital with a temperature of 101.5°F. and marked tenderness of the abdomen just to the right of the umbilicus. He was given penicillin with temporary improvement and on August 20, 1945, an exploratory laparotomy was done.

The pathological findings of the specimens removed were: (1) ileotyphlitis, regional, subacute and chronic, severe; (2) stenosis, terminal ileum, moderate; (3) adhesions, peritoneal,

ileocecal, fibrous, moderate; (4) peritonitis, fibrous, subacute, moderate; (5) carcinoid, appendix. The ascending colon was resected to the transverse colon; 2 to 3 feet of ileum were also removed. A colostomy and ileostomy were performed. The carcinoid of the appendix was apparently an incidental finding. His immediate postoperative course was satisfactory but he continued to lose weight. He complained of nausea, abdominal discomfort, and occasional vomiting. A Wangensten tube was passed during the time that the patient was being transported to this hospital with the notation that it was functioning well.

On admission to Schick General Hospital he appeared emaciated and complained of abdominal discomfort and weakness. Nevertheless, he asked for food. On the morning after admission he complained of mild sacroiliac pains. Later that morning he became very thirsty and drank about 4 pints of water. In the early afternoon he suddenly collapsed, called the ward master and told him he was going to die. When the ward officer arrived shortly thereafter he found the patient moribund and pulse unobtainable. The patient vomited watery stomach contents. There was no chest pain and no paroxysmal dyspnea. He died within a short time after the onset of his symptoms.

Autopsy findings revealed the following: The body was that of a young colored male about twenty-five years of age. There was evidence of marked emaciation and weight loss with marked atrophy of the subcutaneous fat and diminution in width of the skeletal musculature.

No definite abnormalities were seen in the brain. The heart weighed 225 Gm. and appeared small in size and central in position. The parietal pericardium was thin. The pericardial cavity contained no increase of fluid. The visceral pericardium was smooth and glistening. The valves showed no thrombi or vegetations. The right auricle contained a large mass of postmortem blood clot. This was con-

tinuous with a similar clot which partly filled the pulmonary artery and extended for some distance into the left pulmonary branch. Careful examination showed it to resemble in all essential details the mass of clotted material in the right auricle. No organization or attachment to the vessel wall were found. Its surface was smooth and its outline regular, tapering off as it continued into the distal portion of the vessel. The ventricular and auricular cavities were of usual size. There was no dilatation of the right heart. The myocardium was of brown color. It showed no scars or infarcts. The coronary arteries were smooth and patent throughout. The aorta was smooth and elastic. A minimal degree of atherosclerosis was seen at the origin of this vessel. The measurements of the heart were: mitral valve 8.5 cm., aortic valve 5.5 cm., pulmonic valve 6.0 cm., tricuspid valve 11.0 cm. myocardium left ventricle 1.1 cm.

Microscopically, the muscle of the left auricle appeared vacuolated over large regions with the cytoplasm of the muscle cells having been replaced by a faintly staining pinkish serum-like material. A similar appearance was seen in the superficial layer of the ventricular myocardium. The remainder of the myocardium was natural. It was thought that this picture represented atrophy of cardiac muscle. The blood clot in the pulmonary artery consisted principally of fibrin, red blood cells and white blood cells. The periphery was made up mostly of fibrin in which red blood cells were sparingly included. The center was made up of red blood cells and masses of white blood cells including polymorphonuclears, which predominated, and lymphocytes. Large masses of red blood cells were seen interposed between the small collections of white blood cells. There was no evidence of organization and no aggregated masses of platelets. The aorta showed a minimal degree of atherosclerosis.

The lungs were of usual color but seemed to be voluminous. The right lung weighed 500 Gm.; the left lung 400 Gm. Neither showed any evidence of inflammation or infarction. The pulmonary vessels were dissected but no thrombi or emboli were found in either right or left pulmonary arteries or veins. On section both lungs and particularly their lower lobes showed a moderate degree of pulmonary edema. Both lungs showed slight scarring of the apices, with the left apex showing emphysematous blebs.

No hemorrhages or infarcts were seen. The bronchi were of usual appearance but contained a slight amount of frothy material. The tracheobronchial lymph nodes were markedly enlarged. One such group 4.0 by 3.0 by 2.5 cm. was markedly softened and on section was found to consist principally of yellowish amorphous and caseous material.

The abdomen was flat except for a slight prominence in its mid-portion. A fluid wave, however, was felt over this area. A large scar was seen extending from the right hypochondrium down to the pubic region, being 16.0 cm. in length. At the mid-portion of this surgical scar and at the level of the umbilicus, there was a double intestinal opening 4.0 by 2.7 cm. The wound margins showed granulating surfaces but were otherwise free from exudate or suppuration. On opening the abdominal cavity no increase of peritoneal fluid was found. The relationship of the stomach and intestines was markedly disturbed. Covering the entire anterior surface of the abdominal cavity, except for a small portion of liver which projected 3.0 cm. below the costal margin, was a huge dilated stomach, which extended down to the pubis. The length of the organ from fundus to its inferior margin (at the pubis) was 35 cm. The width of the undissected organ from lesser curvature to greater curvature at its midaxis was approximately 15.0 cm. The wall appeared of somewhat less than usual thickness but was not markedly thinned. It appeared greatly enlarged rather than distended; it was of usual color. A network of dilated vessels were seen on the surface. The dilatation extended to the pyloric region and to the proximal portion of the duodenum, which appeared dilated to about twice its usual size. (Fig. 1.) On section the stomach was found to contain 2,350 cc. of thick viscid material, apparently incompletely digested food. No definite articles of food could be discerned except that some white pieces resembled curdled milk. The gastric contents contained mucin and were bile tinged. The stomach rugae were absent. The mucosa showed no scars, ulcerations or hemorrhages. The duodenum was found drawn to the right and to be attached to the lateral abdominal wall and to a large scarred mass which included the two intestinal stomas, adjacent fibrosed peritoneum and peritoneal fat. The omentum appeared very thin and contained little fat. On incising this scarred mass, it was found to con-



FIG. 1. Dilated stomach filling almost the entire anterior abdominal cavity:  
A, fundus; B, antrum; C, liver.

sist principally of peritoneal adhesions, and of fibrous tissue deposition around the stomas, and particularly about the proximal end of the colon. A number of enlarged, firm, rubbery glands, the largest 1.5 cm. in diameter, were found in this region. The duodenum was found to be continuous with the jejunum but appeared narrowed and kinked over the scarred mass. One intestinal stoma appeared in a loop of transverse colon 8 cm. long, and the other lying along side of it was in a loop of ileum. The remaining small intestine measured 90 inches. The cecum, including the appendix, ascending colon and a considerable portion of the distal ileum were apparently removed at operation. No tumor masses were encountered at this region. The small intestine appeared of usual width. The large intestine, particularly from the lower descending colon downward, appeared collapsed. Fecal material could be expressed from this intestine but the quantity was small.

The weight of the right kidney was 150 Gm., of left 120 Gm. The capsules stripped with ease revealing smooth surfaces. The perirenal fat was decreased in amount. On section the parenchyma appeared congested. The width of the cortices was 0.5 cm. and the width of the pyramids beneath the cortices was 1.1 cm. No gross lesions were seen. The pelves were of usual appearance. The ureters were of usual caliber and showed no gross lesions.

The spleen weighed 50 Gm. The organ ap-

peared small and flattened. The surface was slightly wrinkled and the capsule was not thickened. On section the organ was found to be homogeneous and moderately soft. The pulp scraped easily. The remaining abdominal organs showed no marked abnormalities, nor were any definite abnormalities seen in the extremities.

Anatomic diagnoses were: (1) Regional ileitis; (2) carcinoid of appendix (reported at another military hospital); (3) partial colectomy; colostomy; ileostomy; (4) dilatation of stomach, extreme, acute and chronic; (5) dilatation of proximal portion of duodenum; (6) intestinal adhesions around the colostomy, the ileostomy and the proximal duodenum; (7) caseation of tracheobronchial lymph node; (8) pulmonary edema, incipient, and (9) myocardial atrophy, left auricle.

#### COMMENT

This case is unusual in that death occurred apparently due to gastric dilatation forty days postoperatively. The stomach had reached enormous proportion filling almost the entire anterior abdominal cavity and part of the pelvis. The stomach actually appeared to be enlarged rather than distended. It contained not only bile stained fluid but also undigested food. That by itself is not strange, since most of the

cases reported occurred a short time post-operatively whereas this patient was getting a full diet. In spite of this extraordinary dilatation, he did not manifest any marked symptoms, and vomiting was sporadic and only toward the end. The mode of death was rather sudden, the patient showing neither the acute dyspnea and cyanosis of sudden cardiac circulatory insufficiency, nor that of toxemia with vomiting, dehydration and alkalosis. Unusual, too, was the fact that there was no marked abdominal distention, so that at autopsy the abdomen was almost scaphoid.

Acute dilatation of the stomach was first described by Kundrat,<sup>1</sup> Fagge,<sup>2</sup> and Rokitsanski.<sup>3</sup> The pathogenesis of acute dilatation of the stomach is usually stated to be neurogenic.<sup>4,5</sup> There is a gastric paralysis due to sympathetic stimulation, the sympathetic nerves exerting an inhibitory effect on the stomach. There is usually some obstruction at the duodenum, though this is only of secondary importance,<sup>6</sup> sometimes produced by the dilatation of the stomach itself with consequent dragging down of the mesentery, as the duodenum and jejunum are pulled toward the pelvis. Following this gastric ileus the stomach is unable to propel the gastric secretions which according to Dragsted<sup>4</sup> are about 2,000 to 3,000 cc. per day. What initiates this neurogenic inhibitory reflex, sometimes hours or days after an operation is unknown. Nor is it known why in most postoperative cases the ileus should be intestinal while in others it should be gastric.<sup>7</sup> For normal physiology it is necessary that the gastric secretion be able to reach the intestines and be absorbed. Dragsted<sup>4</sup> has further shown that by sectioning the stomach at its cardiac and pyloric portions and subsequently anastomosing the esophagus and duodenum, but allowing the gastric juice secreted by the remaining stomach to be spilled through a fistula, the animals died in six to eight days, in spite of their being able to swallow food and pass it to the intestine. Death was due to the loss of chlorides, an increase of carbon dioxide combining power and a

shift of the hydrogen ion concentration of the plasma to the alkaline side; it could be prevented by the administration of physiological saline.

During dilatation of the stomach the contents do not reach the intestines either due to stasis or vomiting, with resultant disturbance of the electrolyte relationships in the body. But aside from the chemical aspects of this condition, there are also possible deleterious effects from altered blood flow in the coronary circulation. Thus Gilbert, Fenn and LeRoy<sup>8</sup> showed that coronary blood flow may be reduced in dogs following mechanical distention of the stomach. They also state that "In view of the fact that this reduction of flow does not occur after vagal section or after the administration of atropine, it is difficult to escape that conclusion that a reduction of coronary flow is the result of activity of the vagus nerve. This then is an instance of reflex coronary vasoconstriction initiated by vagal irritation in the gastrointestinal tract."

In our case, the patient had the setting for the possible occurrence of this condition. He showed the effects of malnutrition, with marked weight loss, and had duodenal obstruction. The latter was not merely transient or temporary but was very definite and of a considerable degree. His stomach dilatation had probably existed for some time but some new factor supervened, possibly the drinking of a large quantity of water, which precipitated a further acute dilatation with sudden collapse and death. The possible occurrence of such a sequence of events has been mentioned by Doolin<sup>9</sup> who states, "For the passive condition of atony to pass over into the active state of dilatation the stomach must be overloaded either with solid or liquid food or with gas. The rapid ingestion of injudicious quantities of food or drink under such circumstances may easily be the starting point of acute dilatation."

As to therapy, Dragsted<sup>10</sup> has described it in detail. It consists essentially of the following: (1) Early recognition, (2) pos-

tural change to prone position, (3) lavage every four to six hours until no more characteristic fluid is obtained, and (4) parenteral administration of physiologic saline. With this routine he reports that the mortality can be greatly reduced.

#### SUMMARY

1. A case of acute and chronic dilatation of the stomach with sudden death is described.

2. Some of the factors in its pathogenesis have been mentioned.

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PYLORIC occlusion with secondary vomiting and dilatation of the stomach occurs either from cicatricial contraction or from the swelling and edema associated with an ulcer. Rare complications are the occlusion of the bile duct with stone formation and jaundice; and pancreatitis from invasion of the pancreas or obstruction of a pancreatic duct.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

# POSTOPERATIVE OBSTRUCTION OF BILE DUCTS TREATED WITH VITALLIUM TUBE

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OBSTRUCTION of the bile ducts occasionally follows operations for diseases of the bile tract, more commonly after cholecystectomy. Various types of ductal repair have been used to cure this condition but, up to the present time, operative results have been uncertain and often satisfactory. A more favorable approach to this problem may perhaps be arrived at by intelligent analysis of the various methods used to re-establish biliary continuity and the results obtained by these procedures in the different clinics. It is the purpose of this paper (1) to discuss briefly the causes and prevention of operative trauma to the bile ducts, (2) to emphasize some of the more recent surgical concepts and experiences in the cure of secondary bile duct stenosis, especially in relationship to the use of permanent vitallium tube implants, and (3) to report three new cases of postoperative obstruction of the bile ducts which were treated with vitallium tubes.

The etiology of secondary bile duct obstruction is usually inadvertent injury of the extrahepatic biliary tree in the course of an operation for cholecystectomy or choledochostomy; less often it is occasioned by inflammatory cicatrization and stenosis of the bile ducts predicated upon underlying disease of the gallbladder. As a result of either of these factors, the lumens of any portion of the biliary tree from the liver hilus down to the duodenal termination may be partially or totally compromised. The flow of bile is then either deflected to the exterior through a fistulous tract or else the bile is retained in the obstructed ducts.

A review of reports from different clinics

indicates that operative accidents in the course of gallbladder surgery may occur even in the most expert of hands. The hepatic ducts, common hepatic duct (hepaticus) and the common bile duct (choledochus) are not infrequently ligated, clamped, cut or excised and strictures and fistulas are formed. In a group of twenty-three cases of stricture of the bile ducts reported by Cole et al.<sup>4</sup> 76 per cent were related to previous operation; in Walters'<sup>15</sup> group of similar cases 90 per cent followed cholecystectomy. Cattell<sup>3</sup> noted a relationship to operative trauma in 80 per cent of his cases. The causes of secondary obstruction in the remainder of the cases that were not related to operative trauma were the following: (1) ulceration of ducts produced by stones, (2) cicatrizing cholangitis, (3) pyelephlebitis, (4) abscess about ducts, (5) strictures secondary to pancreatitis, and (6) extra and intraductal growths.

The usual uncomplicated operation for cholecystectomy is technically simple. However, in certain instances, there may be difficulty in recognizing and isolating the various blood vessels and bile duct structures which are associated with the procedure; it is in this group of cases that accidental injury of the bile ducts may occur. One of the reasons for this is the common incidence of congenital anomalies of the extrahepatic biliary tree as well as of its accompanying vascular components. When these anomalies are present the entire topography of the gallbladder area may be confused. Another reason for the difficulty in isolating the essential structures in the operation for cholecystectomy is the distortion of the normal anatomical

landmarks which is commonly the result of infection. A third, and perhaps less frequent cause, is the incidence of local hemorrhage and resultant obscuring of the operative field. These are the factors which occasionally challenge the surgeon's skill and ingenuity.

In the presence of congenital anomalies, inflammatory distortion or local bleeding, the exercise of extreme caution and the observance of a few basic principles in the prevention of operative trauma may perhaps avert some fortuitous mishaps. To begin with, good exposure of the operative field is most important. Complete walling off with laparotomy sponges and retraction of the surrounding organs is essential for clear visualization of the entire cystic pedicle and of the hepatoduodenal ligament. Furthermore, it is necessary that the cystic artery and duct be separately exposed and ligated in the sequence mentioned. The cystic duct should be dissected down to its confluence with the common duct and both structures must be clearly identified before ligating the cystic duct. Finally, if the gallbladder is long and the cystic pedicle is located at great depth in the abdomen, or if anatomic distortion is present, of either anomalous or inflammatory nature, there is indication for subserous dissection of the gallbladder commencing at the fundus and extending downward toward the cystic pedicle. This is a slower but safer procedure under the condition just described than mobilization of the gallbladder from below upward since the vascular and duct structures are more easily identified.

Two general principles of procedure are utilized in the repair of bile ducts which have become occluded after operation on the bile tract. The first consists of re-establishing the interrupted continuity of the affected ducts by utilizing any of the following measures. (1) dilatation of the occluded portion of the ducts, (2) division of the stricture, (3) excision of stenotic portions and end-to-end anastomosis, and (4) plastic repair of the Heinecke-Mikulicz

type. The second principle entails anastomosis of the stumps of the hepatic ducts, the hepaticus or of the ductus choledochus to the stomach, duodenum or jejunum. Temporary or permanent implantation of prosthetic tubes at the site of reconstruction may accompany any one of the above procedures. The procedure of choice varies with the condition of the patient, as well as the site and extent of the stenosis.

Common to all operations designed to cure secondary bile duct obstruction is the hazard of recurrent stricture formation at the site of repair. Colp<sup>6</sup> and others have observed that this tendency to recicatrization and stenosis is diminished when there is accurate, sutured approximation of the mucous membranes of the bile ducts and when no tubes are used. However, even under these conditions, rescarring and occlusion at the anastomotic site occasionally recurs. Furthermore, mucous membrane approximation is not feasible in many instances; the duct defects are often too long to permit anastomosis of the two ends without there being dangerous tension at the suture line. In these cases prosthetic tubes are temporarily or permanently implanted to bridge ductal gaps and to maintain patency of their lumens.

In those instances in which direct biliary intestinal anastomosis is necessary, the hazard of recurrent stenosis is supplemented with the additional danger of ascending infection. The absence of a valve, analogous to the sphincter of Oddi, favors regurgitation of intestinal contents into the extrahepatic and intrahepatic ducts. As a result, ascending cholangitis is a common complication and occasionally multiple liver abscesses are formed. This operative procedure has, therefore, been reluctantly resorted to for want of a more successful method of repair in cases in which the distal end of the obstructed bile duct is completely stenosed or when it is absent. Although many such cases may remain well for years—Eliot<sup>7</sup> noted that eleven patients in a collected series of forty-one cases were free from ascending

infection for ten to twenty years after operation—the majority deteriorate rapidly and succumb to infection. Prosthetic tubes, implanted at the site of biliary intestinal anastomosis are helpful in maintaining patency of the lumen but they do not impede the reflux of food from the bowel into the bile ducts.

Repair of postoperatively obstructed bile ducts has been greatly facilitated in the past by the use of rubber tubes. These have been of some value in bridging ductal defects and in keeping anastomotic sites patent especially where mucous membrane anastomosis was not feasible. On the whole, however, rubber is not well adapted for use in this part of the body for the following reasons, namely, (1) it deteriorates rapidly, (2) rubber tubes slip out of place easily and within three to twelve months after they do so signs of obstruction develop, (3) rubber activates fibroblastic proliferation and scarring, and (4) it promotes precipitation of bile salts and pigments and thus occlusion of the tubes. Exceptional cases have been reported in which rubber tubes remained in place and functioned for long periods of time. In one instance Judd<sup>8</sup> reported the retention of such a tube with good function for four years after which time the lumen became occluded and ascending infection resulted. Andrus<sup>1</sup> cited a case in which the tube functioned well for eight years. As a rule, however, rubber begins to deteriorate in one year.

In 1941, Pease<sup>10</sup> experimented with tubes made of vitallium, an alloy of cobalt, chromium and molybdenum. This metal had been found to be inert in other parts of the body and it proved to be better adapted than rubber to the conditions which exist in the biliary tract. When vitallium tubes were implanted in the common ducts of dogs the metal did not appear to deteriorate. Furthermore, there was no deposition of bile salts or pigments on the surface of the tubes and the mucosal lining of the ducts showed practically no histomorphological changes.

The first straight vitallium tube devised

measured 4 cm. in length and 6 mm. in the width of the outside diameter. They are now standardized to the length of 3.3 cm. and a diameter of 6 mm. A central flange consisting of a flat piece of metal 4 to 6 mm. high is welded on the middle of the tube. This facilitates manipulation of the smooth cylinder; it also serves as an anchor at the point of anastomosis since it helps to prevent the tube from slipping up or down. The eye of the flange is adaptable for fixation of tension sutures when it is necessary to relieve tension on the line of anastomosis. Some tubes are modified in both size and shape to adapt to the different parts of the biliary tree. Clute first utilized a tube with a trumpet-shaped end in a patient in whom a very short common hepatic duct was anastomosed to the common duct. The horn-shaped end was designed to act as a funnel for the bile from both hepatic ducts. Y-shaped tubes, half Y and fenestrated tubes are constructed for the same purpose. Angulated tubes are made to adapt to the inclinations and directions of the bile ducts.

The vitallium tube has been but rarely used up to the present time in the repair of injured bile ducts. Only a few instances are cited in the literature of its clinical application in interductal reconstruction. Pease<sup>11</sup> reported his experience with three patients. In the first case a stricture of the hepatic duct was incised, a metal tube was implanted at this point and the duct was repaired over the tube. In another instance, a metal tube was used to fill a long gap between two patent ends of a common duct. A third vitallium tube, in another patient, bridged a space between the hepatic and common ducts. Seaman<sup>12</sup> cited two cases which were identical to the first and third patients reported by Pease. Migliaccio<sup>9</sup> described his experience in a case in which a metal Y tube was implanted between the two hepatic ducts and the common duct. In all the above patients, one or more previous attempts to repair the obstructed ducts had failed, whereas the final operation utilizing metal tube



implants and supplementary anastomosis were all successful. Cole et al.<sup>4</sup> employed vitallium tubes to connect the stumps of the hepaticus and choledochus in two cases. One patient remained entirely well; the other succumbed from peritonitis eight weeks after operation.

Originally, the vitallium cylinder was not intended for use in biliary intestinal anastomosis because all the different tubes which were put to this use in the past tended to become dislodged by the food stream and passed into the intestine. There inevitably followed recurrent stricture formation at the site of the stoma. However, a number of cases of biliary intestinal anastomosis with vitallium tube implants have appeared in the literature. The central flange on these tubes appear to serve as a relatively satisfactory anchor; it prevents the cylinder, in most instances, from slipping into the bowel. Carlucci's<sup>2</sup> paper describes a case in which, after four previous operations, biliary intestinal continuity was successfully established by using a metal tube implant in the final operation of choledochogastrostomy. This case was observed for nine months after operation and recovery was complete. Sternfeld<sup>11</sup> and Meffley treated a patient with complete stricture of the common duct by hepaticoduodenal vitallium tube intubation supplemented by hepaticoduodenostomy. Cole et al.<sup>4</sup> reported the use of metal tubes in ten cases of hepaticojejunostomy; in two instances the tube became dislodged after several months but no succeeding stenosis resulted. Cole<sup>5</sup> is of the opinion that, if the biliary intestinal stoma is of sufficient dimension to permit a metal tube and its projecting flange to pass through it, the patency of the stoma will be maintained.

At the Illinois Research Institute, Cole and his co-workers also examined these cases for an answer to the problem of intestinal reflux and ascending infection of the biliary tree. They sought, at first, to shunt the intestinal contents away from the bile tract by implanting the proximal end

of the common duct into a long loop of jejunum with the aid of a vitallium tube and by performing an entero-anastomosis proximal to the biliary stoma. This was unsuccessful in five cases; they all developed ascending infection of the bile ducts. A procedure was then evolved which appeared to prevent the regurgitation of food into the bile channels. To accomplish this, an arm of jejunum twenty-four inches in length was anastomosed over a vitallium tube to the duct stump at the liver hilus after the principle of Roux. This was supplemented by the creation of a series of valves in the defunctionalized loop of intestine by simply infolding the wall with a double row of seromuscular sutures. Five patients treated in this way had excellent results.

In the past five years three cases of postoperative obstruction of the bile ducts were treated at the Jewish Hospital of Brooklyn with vitallium tubes. In one case a choledochojejunostomy was performed to circumvent what appeared to be an obstructive kink in the terminal bile duct; in another patient a hepaticoduodenostomy was done for constriction of the choledochus; and in the third instance, a hepaticoduodenostomy was necessitated by the absence of the distal end of the common duct.

#### CASE REPORTS

CASE II. L. K., a white male, seventy years of age, was operated upon at another hospital for chronic calculous cholecystitis two months before his admission to the Brooklyn Jewish Hospital. After cholecystectomy in the former institution his recovery was uneventful except for a persistent biliary discharge at the site of drainage. He was discharged four weeks after operation and soon thereafter he noted increasing symptoms of weakness and tiredness. Bile drainage from the abdominal fistula continued and the stools were occasionally clay colored. One week before admission to the Jewish Hospital the patient began to suffer from upper abdominal pain and recurrent chills and fever.

Physical examination on admission revealed the patient to be a fairly well nourished male

who did not appear to be acutely ill. The conjunctivae and skin were slightly icteric. The heart and lungs were not unusual; the blood pressure was 140/88. The abdomen was soft and relaxed. No masses or organs were palpable; the liver was not enlarged. There was a healed 6 inch transverse subcostal scar on the right, at the medial end of which golden yellow bile drained through a small sinus. Rectal examination was negative. Peripheral blood study showed moderate secondary anemia; the white blood count and differential count were not unusual. Blood serum examinations revealed the icteric index to be 18.8; the value for phosphatase was 13.9 units and the prothrombin time was 7.9. Cephalin flocculation was negative and sedimentation rate was 50 mm. in one hour. The stools contained no bile and showed a 2-4 plus reaction to benidene. The urine gave a 2 plus reaction for bile and was negative for urobilinogen. A preoperative diagnosis was made of obstruction of the bile ducts. The patient was prepared for operation. Measures were taken to restore to normal balance the blood electrolytes, proteins and vitamins, as well as the prothrombin time.

Under spinal anesthesia the fistulous bile tract was traced down to the open stump of the cystic duct. The common duct was very edematous and three large, firm lymph glands were palpable in the retroduodenal area. The duct was opened and it contained golden yellow bile. A flexible probe and a soft rubber catheter both passed easily upward into each hepatic duct and downward into the duodenum. The liver, pancreas, stomach, duodenum and colon were normal. There was no evidence of an intrinsic or extrinsic lesion which might compromise the lumen of the common duct. It was, therefore, assumed that the persistent biliary fistula was due either to subsiding inflammatory edema of the common duct or extrinsic pressure of enlarged paraductal lymphatic glands; more probably the former. A Kehr T tube was inserted into the common duct and the abdomen was closed. Bacteriologic studies of the bile removed from the common duct showed gram-negative bacilli on smear and *Bacillus coli* on subsequent culture.

Immediately following operation 200 to 600 cc. of bile drained through the T tube daily. Blood chemistry figures were within normal limits; icteric index was normal. The stools were light brown; they showed 2 plus guaiac



FIG. 1. Dilated intra- and extrahepatic bile ducts filled with dye. In the terminal portion of the common bile duct is seen a round shadow suggestive of stone formation.

tests for blood. The patient appeared to be in good condition. On the fifteenth and on the twenty-fifth days after operation cholangiograms were done through the T tube. On each occasion the opaque dye was retained within the dilated bile ducts; none of it escaped into the duodenum. There appeared to be a sharp rounded defect at or near the ampulla of Vater resembling a calculous which produced a complete block. (Fig. 1.) On the twenty-sixth day after operation the stool was again clay colored, the urine contained bile and the patient was slightly icteric. An attempt to clamp off the T tube resulted in severe abdominal pain. The clinical course of this case and the cholangiographic findings appeared up to this point to be identical with that of a similar case previously reported by Pines and Rabinovitch<sup>12</sup> in which a residual calculous was suspected but instead there was found at the third operation a carcinoma of the terminal portion of the common bile duct. The similarity of the sharp, round, circumscribed cholangiographic defect in the terminal duct in both cases was striking. It was, therefore, also believed that in the present instance a duct neoplasm might be present. Studies of the rugal pattern of the second por-

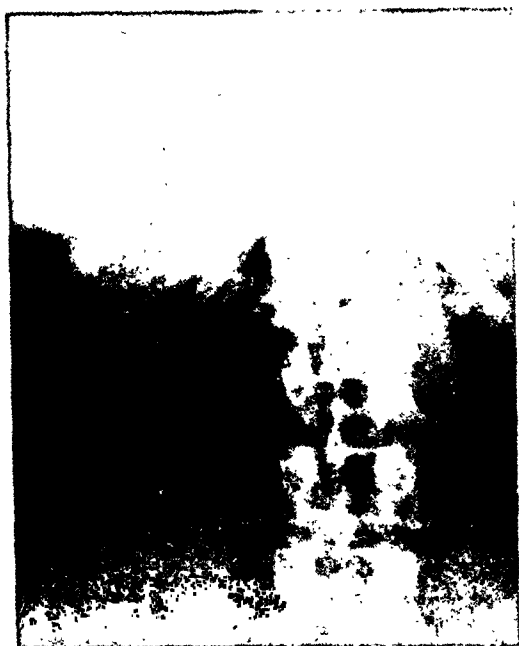


FIG. 2. Straight vitallium tube is seen located in the position in which it was implanted three years before.

tion of the duodenum were unsatisfactory. A Best-Hickens régime was administered for the purpose of expelling any impacted calculi which might have been overlooked in the common duct; this produced no change in the clinical picture or in the subsequent cholangiograms. The stools showed a 2 plus reaction to benzidine.

The patient was again prepared for operation. Under continuous spinal anesthesia the abdomen was opened through the same incision. The common duct appeared slightly widened and thickened but it was otherwise normal. No stones or masses were palpable. Flexible sounds and soft rubber catheters again passed easily upward into the hepatic ducts and downward into the duodenum. A duodenotomy was performed and no changes were noted in terminal bile duct, papilla of Vater or duodenum. Catheters passed easily upward into the ducts. No changes were seen in the pancreas or in the other adjacent organs. The only remaining possible etiologic factors for the obstruction of the common duct in this case appeared to be either intractable spasm or kinking at, or near, the ampulla of Vater. The complete failure of antispasmodics, nitrites and of the Best-Hickens régime to relieve the bile duct obstruction even partially seemed to militate against the factor of spasm. The latter possibility was also conjectural since no definite point of

angulation of the duct could be demonstrated at operation. However, it was believed that the density of the retroduodenal tissues did not permit clear visualization of the course of the duct and that a common duct kink was the more probable cause of the obstruction in this case. The common duct was mobilized and severed at the point where the T tube had entered. The proximal end was purse stringed over one end of a standard sized, straight vitallium tube and then the eye of the flange of the tube was transfixed. The distal end of the common duct was doubly ligated. The free end of the vitallium tube was then implanted and purse stringed into a loop of jejunum about two feet distal to the ligament of Trietz. A row of interrupted seroserosus black silk sutures completed the choledochonjejunostomy.

The stools became normal in color immediately after operation and remained so. Within two weeks after operation the blood chemistry figures and the icteric index were normal. The wound healed completely and the patient was discharged on the twenty-fifth day after operation fully recovered. Close observation for three years, that is, to the present time shows the patient to be in excellent physical condition. There have been no signs or symptoms referable to the abdomen. The patient has gained 30 pounds in weight since his discharge from the hospital. A recent flat plate of the abdomen reveals the vitallium tube implant in the right upper quadrant in the same position as that in which it was originally fixed. (Fig. 2.)

CASE II. T. K., a white female, fifty-two years of age, was operated upon for chronic calculous cholecystitis at another hospital two months before her first admission to the Jewish Hospital. Three days after the cholecystectomy was performed the patient developed jaundice of an obstructive nature. This continued intermittently for two months when she suddenly noticed a mass in the right upper quadrant. On admission to the Jewish Hospital there was no clinical jaundice. No bile was found in the stools; the icteric index was 16. A preliminary incision and drainage was performed to empty a large collection of green, bile stained thin fluid from the subhepatic space on the right. One month after admission to the Jewish Hospital the patient was prepared for reoperation for obstructive jaundice.

Exploration under spinal anesthesia revealed cicatricial contraction of the common duct at

its junction with the cystic duct. The anterior wall of the duct proximal to the cicatrix was perforated. The cicatrix was incised and a T tube was inserted into the common duct. Two weeks after operation the stools contained bile and there was very little drainage through the T tube. Cholangiograms showed the dye passing freely through the T tube into the duodenum. The patient was discharged one month after operation apparently in good condition with the T tube *in situ*.

Several days after being discharged from the hospital the T tube became dislodged. The patient then began to suffer from intermittent attacks of chills, fever and jaundice and she was readmitted to the Jewish Hospital three months later. On physical examination the patient was fairly well developed showing evidence of recent weight loss. The skin, conjunctivae and mucous membranes were icteric. There was heard a blowing apical systolic murmur and the heart was slightly enlarged. A mass was palpable in the right upper quadrant which moved with respiration. The stools were clay colored; the urine contained urobilinogen in 1:1 dilution and it was positive for bile. The blood phosphatase was 15 units; the icteric index was 35; the van den Bergh showed a direct biphasic reaction and an indirect measure of 5.2 units per 100 cc. of serum.

The patient was again prepared for operation for obstructive jaundice. Under cyclopropane anesthesia, the abdomen was opened and the common duct was re-explored. At the site of the supraduodenal portion of the common duct a portion of the anterior wall was absent; above the defect the duct was dilated. The liver was cholemic in appearance. The dilated portion of the hepatic duct was incised longitudinally and one end of a standard vitallium tube was fixed into it with black silk sutures. The other end was fastened into the first portion of the duodenum with a purse-string suture. A series of seroserosus sutures completed the hepaticoduodenostomy.

The postoperative course was uneventful. At discharge twenty-four days after operation a slight amount of bile drainage was present at the site of the removed drains. The stools contained bile. Since the operation six months ago, the wound has healed completely and there have been no untoward signs or symptoms.

CASE III. H. O., a thirty-two year old white male, was operated upon for chronic calculous cholecystitis at the Brooklyn Jewish Hospital.

During the cholecystectomy the common hepatic duct was inadvertently severed. A silk ureteral catheter was implanted at the site of injury and the duct was reconstructed around it. After the operation, there developed a massive pulmonary atelectasis. Bronchoscopy was done and a mucous plug was aspirated. Recovery was then uneventful. After discharge from the hospital the patient noted increasing weakness, anorexia and loss of weight. Ingestion of food caused abdominal distress. Three weeks before readmission there developed jaundice and pruritus.

Physical examination on readmission revealed clinical icterus and secondary dermatitis factitia. The liver was palpable four fingers below the costal margin. The stool contained bile and a faint trace of blood. The urine also contained bile. The icteric index was 64.7 and the van den Bergh showed a direct biphasic reaction and an indirect quantitative measurement of 11.9 units.

After adequate preparation the patient was reoperated upon five months after the original operation for cholecystectomy. Under fractional spinal anesthesia the abdomen was reopened and extensive adhesions were carefully freed. The liver, hepatic flexure of the colon, stomach and duodenum were identified and retracted away to expose the hepatoduodenal ligament. Careful dissection failed to reveal the distal end of the common bile duct even after mobilization of the duodenum to the left. The proximal end of the common hepatic duct was located and one end of a vitallium tube was fixed in the lumen with black silk sutures; the distal end of the cylinder was inserted and purse-stringed into the first portion of the duodenum. The anastomosis was completed with interrupted silk seromuscular sutures. A patch of omentum was used to reinforce the suture line.

Postoperatively, all signs of obstruction of the bile ducts gradually disappeared and the wound healed *per primum*. The patient was discharged in good condition and he has remained well for four years.

#### SUMMARY AND CONCLUSIONS

Three cases are reported of postoperative obstruction of the bile ducts which were treated with permanent vitallium tube implants. In one instance, a unique condition of obstructive kinking of the ter-

minal portion of the common duct was cured with choledochojeunostomy over a tube implant. In another case, choledocho-duodenostomy over a metal cylinder was successful in the treatment of cicatricial contraction of the common duct at its junction with the cystic duct. A third patient, in whom the distal end of the common duct could not be found, was completely restored to health by the implantation of a vitallium tube between the cut end of the hepatic duct and the duodenum and supplementary hepatoduodenostomy.

The treatment of injured bile ducts must be individualized after careful consideration of the general condition of the patient, the type of injury and its location. There can be no successful stereotyped approach. The results of the various operative methods which have been used up to the present time, have not been entirely satisfactory; recurrent strictures and ascending infection of the biliary tree are not uncommon. The best results are obtained in the presence of local duct structures which can be resected and then repaired with accurate primary sutured approximation of the cut ends without the use of adjuvant prosthetic tubes. In those cases in which slight tension is present at the line of anastomosis a T tube may be used; the tube must not be brought out through the line of repair but through an incision in the duct distal to it. When suture line tension is marked or a long gap or stricture is noted, a permanent tube implant is essential. This also pertains to those cases in which the terminal portion of the common duct is constricted or absent and biliary intestinal anastomosis is indicated.

Vitallium tubes appear to be better

adapted to implantation in the bile tract than do either rubber or silk tubes; they do not become corroded, irritate the duct mucosa, or encourage deposition of bile salts in the tube lumen. Recurrent cicatrization and stenosis is therefore less apt to occur. In cases of biliary intestinal anastomosis vitallium implants appears to be satisfactory inasmuch as they do not become dislodged easily. Even when they do become dislocated the patency of the new stoma appears to be maintained.

Encouraging progress is noted in the prevention of intestinal reflux and ascending bile tract infection in cases of biliary intestinal anastomosis. This complication is apparently best avoided by shunting the intestinal contents away from the new stoma utilizing the method employed by Cole and his coworkers. In this procedure, a long arm of jejunum is anastomosed to the bile duct stump over a vitallium tube after the principle of Roux and a series of valves are created in the defunctionalized loop of intestine.

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# MENINGEAL IRRITATION AND ACUTE RISE IN INTRACRANIAL PRESSURE FOLLOWING USE OF CELLULOID PLATE FOR CRANIOPLASTY\*

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AT this particular time, and for some time to come, many patients with skull defects will need plastic repair of their cranial wounds. Since the surgeon has to select the proper material for this type of work, any observation which may help him in his decision should be recorded.

## CASE REPORT

In May, 1937, an eight-year-old boy sustained a compound fracture of the skull with protrusion of brain substance and leakage of cerebrospinal fluid in the left occipital region. He was admitted to another hospital, where, on neurological examination, evidence of extensive damage to the left hemisphere was found. Two months after the accident, the patient developed a temperature of 104.0°F., signs of meningeal irritation and a cerebral hernia. Both the cerebrospinal fluid cell count and total protein content were markedly elevated, but there was no sign of invasion of the meninges by a micro-organism. Within three weeks pus was repeatedly aspirated from the hernia and eventually it had to be incised. A large abscess cavity was entered and drained. On laboratory examination, *Staphylococcus aureus* was found. After a temporary improvement in the patient's condition, the abscess cavity, which was found to extend deeply into the brain substance was drained again.

For about six years, the boy did fairly well under anticonvulsive therapy. He attended school and made good progress. In April, 1943, however, he had to be readmitted on account of convulsions, which, lately had increased in frequency and severity.

Encephalography showed the lateral ventricles well outlined, the left being distorted in shape, pulled upwards, and having lost its normal butterfly contour; the right ventricle

was normal; the third ventricle appeared medium in position and slightly dilated; while the fourth ventricle was normal. A small pocket of air in the left hemisphere measuring 2½ cm. in diameter was noted lateral to the ventricle.

The exact location of the cyst could not be stated. The subarachnoid spaces contained only a small amount of air. The skull showed a large bone defect 4 by 6 cm. which was smooth in outline.

The patient was discharged after three weeks, with a diagnosis of post-traumatic Jacksonian epilepsy and old healed brain abscess with scar formation. Surgical intervention was not deemed advisable at that time.

Between March and October 5, 1945, the patient was hospitalized three times in another hospital for repair of his cranial defect and for status epilepticus. The final diagnosis was cortical scar and cerebromeningeal adhesions in the region of the left occipital lobe (post-traumatic convulsive disorder); the left parieto-occipital cranial defect was covered by a plastic plate during March, 1945.

On October 20, 1945, the patient was seen immediately after an epileptic attack. He was still somewhat confused and for some time had difficulty in answering questions. Later, he paced the floor and was highly apprehensive and irritable. He kept on complaining of feeling much worse since the last operation. This statement was confirmed by his father, who reported that the boy had been complaining about severe pain at the operative site ever since, that this pain had increased in intensity and was occasionally associated with nausea and vomiting. On examination, which was incomplete, since the boy would not cooperate, it was found that there was no bulging at the site of the operation, but that the skin in this region appeared to be excessively tender to touch. A few days later, the patient was ad-

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mitted to Morrisania Hospital where a more complete examination was done.

In the left occipital region there was a denuded area, corresponding to a skin flap with a medial margin as a hinge, under which a plate of about 3 by 5 cm. could be felt. The plate moved easily but the movements caused pain.

The neurological examination showed a spastic ataxic gait with weakness of the right lower limb; there was no speech defect; the pupils were dilated and sluggish in their reaction to light and accommodation; the fundi showed a moderate degree of pallor on both sides with secondary optic atrophy; there was right homonymous hemianopsia, right lower facial weakness of central type; the right arm and leg were mildly atrophic with hemiparesis and slight hypertonicity; there was marked right-sided hyper-reflexia, absent right abdominals and positive right Babinsky and Rossolimo; hyperesthesia and questionable hyperalgesia on the left side with increased sensation to temperature and light touch.

A spinal fluid examination was done on October 28th, and showed clear fluid, with an initial pressure of 160 mm. of water, and a final pressure of 70 after the removal of 10 cc., there were no cells, the total protein content was 38.1 mg per cent. The blood count revealed a leukocytosis of 13,800 with 80 per cent polymorphonuclears, 19 per cent lymphocytes and 1 per cent monocytes. The red blood count and urine examination were normal.

On November 7th, without apparent reason, the patient became increasingly lethargic but could be easily aroused. On the next day, he appeared to be very drowsy and could be aroused only with difficulty. His temperature was 101.2°F. and the pulse rate 80. His respirations were deep. After the patient's head had been shaved, it was noted that the operative site was markedly bulging. On palpation, it was felt that the plate was riding, apparently without contact with the surrounding bone. Pressure on the skin overlying the plate and the gap between the plate and the bone gave the feeling of fluctuation. The patient was semistuporous and incontinent. He could be aroused only by painful stimuli and then would resist violently to any manipulation. The fluctuating area was aspirated, care being taken to move the needle tangentially, and to slide close to the inner surface of the plate. Thirty cc. of perfectly clear and colorless fluid were re-

moved, until the protrusion had markedly subsided and had become much softer. Even while the last few cc. were withdrawn, (which on laboratory examination showed 16 polymorphonuclear leucocytes, a positive Pandy and 138 mg. total protein) the patient's behavior changed markedly. He became quieter and when his head was dressed he was looking about and seemed to become aware of his surroundings. During the night, he slept quietly and on the following morning, his behavior was normal. His condition has been good since, and he has been up and around the ward without any complaints.

#### COMMENTS

Indications for repair of cranial defects according to Frank H. Mayfield and Louis A. Levitch, are: (1) Anxiety due to fear of trauma of the brain; (2) Unsightly and large deformity; (3) defects that pulsate and are painful; (4) protection from trauma; and (5) "syndrome of the trephined"—headaches and dizziness with change of position and with cough and extreme intolerance to vibration. Contraindications are: Presence of infection—or recent history of sepsis—or disease that may lead to anticipation of further surgery of the skull or brain in that area.

Various materials have been used for repair of Cranial defects. Autogenous bone transplant for repair of cranial defects is not satisfactory. First, it is an extensive operative procedure to secure bone for grafting and second, there is always the question of survival of the bone fragment as osseous tissue. Foreign materials such as gold, platinum, aluminum, steel, silver, celluloid, vitallium and many more have been used for such plastic operations. Celluloid is known to cause reactive tissue proliferation.

Many of the above mentioned materials have proved reasonably satisfactory; none of them, however, had all the properties that should be found in the ideal substance for cranial repair. Such a substance should not produce inflammation or foreign body reaction when implanted in tissues. It should be strong enough yet malleable to permit molding with reasonable ease.

Tantalum, as reported by Burch and Carney, Pudenz, Mayfield, Levitch and many others, more nearly meets all these requirements than any other material yet used. Tantalum permits cells to attain their normal growth unhampered and, therefore, prevents fixation or traction as well as formation of scar tissues. Normal growth of bone over tantalum fixation plates and skull plates have been reported.

Another problem is the occurrence of increased intracranial pressure, which caused bulging at the operative site and was instantly relieved by withdrawal of 30 cc. of clear, colorless fluid from under the plate. Although we were unable to find any report dealing with protracted or delayed reactions to celluloid plates, it does not appear at all unlikely that cases of this kind were reported at a time when this type of material was more widely used and that these observations have been forgotten, the first patients having been operated upon by Fraenckel in 1895. (That early reactions, consisting of the accumulation of serosanguineous fluid, occur which require aspirations for a period of about two weeks is well known.) In the case under consideration, the accumulation of fluid was doubtless a serous reaction of the meninges, causing bulging of the plate and giving rise to increased intracranial pressure.

Oppenheim and others reported circumscribed cysts of the arachnoid with clear spinal fluid and pleocytosis without presence of any organisms in cases of serous meningopathy. Strauss found aseptic meningitis in brain abscess as a reaction to a focus of infection near the meninges. Margulies and Savitsky consider the latter type of meningeal response a reaction to toxins as well as to unsuccessful invasion of the meninges by hypovirulent organisms.

The possibility that the meningeal reaction was due to loss of camphor from the plastic plate, which occasionally has been seen to occur, should also be considered. It is also possible that bacteria may have

lain dormant in the wound, and after plastic repair contributed to the reaction.

The instantaneous improvement in the patient's condition appears to be due to the relief of intracranial pressure, as it strongly resembles the effect seen during the evacuation of epidural clots or subdural hematomas in the usual, uncomplicated case.\*

#### SUMMARY AND CONCLUSIONS

A sixteen-year-old boy, who sustained a compound fracture of the skull eight years ago, presented a large bone defect in his skull 4 by 6 cm. In March, 1945, his parieto-occipital cranial defect was covered by a plastic plate. In November, 1945, the patient developed signs of increased intracranial pressure with stupor, incontinence, bulging of the wound and signs of fluctuation between the plate and the skull. Aspiration of 30 cc. of clear fluid brought instant relief by decreasing the intracranial pressure.

Removal of the plate which was refused by the patient's family at that time has been carried out since.

Since the celluloid plate caused serious meningeal reaction with increase of intracranial pressure, proper selection of material for cranial repair is of the utmost importance.

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\* Removal of the plate was naturally suggested, but the patient wanted to be discharged at that time. We have since learned that the plate has been removed in another hospital and that a large cyst had been found in the underlying brain probably corresponding to the cavity seen after encephalography, reported above and that no evidence of infection could be seen at operation.



# ABDOMINAL APOPLEXY

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**S**UDDEN intra-abdominal hemorrhage from the pelvic organs in women, spontaneous rupture of an aneurysm within the abdomen, and massive hemorrhage following trauma or in connection with a malignant lesion are all relatively common experiences in surgery; but the condition under discussion here rarely appears twice in any surgeon's records. Spontaneous rupture of a splanchnic vessel has very aptly been designated "abdominal apoplexy" to denote its close resemblance both in spontaneity and nature to the much more frequent and better known cerebral apoplexy. A survey of the literature has revealed but thirty-two cases which might be so classified, the first case, as far as can be determined, being reported by Barber<sup>1</sup> in 1909. To these thirty-two cases, after reviewing the available records at Charity Hospital, three more cases may be added, the most recent being the author's case which will be reported in detail. It is only through the repeated reportings and tabulations of such cases that characteristics, if any, will become recognized which may serve in the diagnosis and treatment of future cases.

## CASE REPORT

The patient, male, age fifty-two, presented himself at Charity Hospital at 2:30 P.M., January 18, 1946, complaining of moderate pain over the entire abdomen and more marked on the left. The patient stated that, two days prior to admission, he experienced a sharp, sudden pain in the left shoulder. This pain radiated down the posterior left half of the thorax, into the left flank, and, finally, across the abdomen to the region of the umbilicus. He had had a good bowel movement the morning before admission and had passed copious quantities of "gas" up until the morning of the date of admission. He had vomited

only slightly and there was no history of melena.

The patient had previously been a patient of Charity Hospital and was discharged July 17, 1945, with a diagnosis of "hypertensive cardiovascular disease with failure."

The general appearance of the patient was one of acute illness, weakness and anemia. Physical examination on admission revealed the temperature to be 100.1°F., pulse 110, respirations 28, and blood pressure 174/88. During his previous admission, his blood pressure was found to be 220/170. Examination of the abdomen revealed a lower mid-line scar resulting from surgery for a gunshot wound of the abdomen several years previously, and marked distention of the lower abdomen. There was generalized direct tenderness and rebound tenderness with little or no rigidity. No peristaltic tones could be heard.

Rectal examination revealed nothing of note except slight tenderness high up on the right side. The prostate was not enlarged.

Examination of the heart revealed that it was moderately enlarged to the left with a systolic murmur at the apex. The rate was rapid and the rhythm regular.

A scout film of the abdomen on admission was of poor quality and, consequently, non-informative. Blood studies revealed: hemoglobin - Gm., 48 per cent; erythrocyte count 2.07; white blood cells 20,850 with 80 per cent polymorphocytes, eosinophils 1 per cent, monocytes 1 per cent and lymphocytes 18 per cent. The venous pressure was 150 and the urinalysis was recorded as essentially normal. The blood urea nitrogen was 40 mg. per cent; the blood chlorides 479.7 mg. per cent. An electrocardiogram taken during his previous stay in the hospital revealed "Definite E.K.G. evidence of myocardial disease."

After the administration of approximately 750 cc. of blood, the patient was taken to the operating room at 7:30 A.M., following the day of admission, with a preoperative diagnosis of mesenteric thrombosis versus adhesions ileus versus perforative sigmoidal diverticulitis with extension to the left subphrenic space. With

TABLE I

Author	Year	Age, Sex	Complaint	Site	Blood Pressure	Arterio-clevisis of Ruptured Vessel	Operation	Result	Autopsy
Barber <sup>1</sup> .....	1909	32 F	Abdominal pain	None definite	Normal	?	Yes	Recovered	Source not found
Churchman <sup>2</sup> .....	1911	48 M	Abdominal pain	None definite	?	?	Yes	Died	
Florence and Ducuing <sup>3</sup>	1913	? F	Abdominal pain	Branch of sup. mesenteric	?	?	.....	Died	
Hilliard <sup>4</sup> .....	1918	48 M	Abdominal pain	None definite	190 Systolic	?	Yes	Died	No
Starcke <sup>5</sup> .....	1923	60 M	Severe epigastric pain	Gastro-duodenal artery	155 Systolic	Marked	Ligation	Recovered	
Budde <sup>6</sup> .....	1925	27 M	Severe abdominal pain	Left gastric artery	?	?	Ligation	Recovered	
Green and Powers <sup>7</sup>	1931	54 F	Severe abdominal pain	Left gastric	260/125	Marked	Ligation	Recovered	
Molines, Cabenac <sup>8</sup> ..	1933	56 M	Gastric upset	Left gastric	Severe	Marked	Ligation	Recovered	
Molines, Cabenac...	1933	.. M	Abdominal pain	Left gastric	230/130	Marked	Yes	Recovered	
Molines, Cabenac...	1933	73 F	?	Left gastric epip.	?	Marked	Yes	Died	Yes
Hartley and McKechnie <sup>9</sup>	1934	31 M	Abdominal pain	None definite	Normal	?	Yes	Died	Yes
Thompson and Dunphy <sup>10</sup>	1935	62 F	Precordial pain	Br. of l. gastric	170/100	Marked	Yes	Recovered	
Buchbinder and Green <sup>11</sup>	1935	57 M	Severe abdominal pain	Rt. gastric artery	190/115	Marked	Ligation	Recovered	
Cutler <sup>12</sup> .....	1936	80 F	Abd. pain; faintness	Br. of rt. colic	200/120	?	Yes	Recovered	
Moorhead and Mc-Lester <sup>13</sup>	1936	50 M	Dyspnea	Sup. mesenteric	220/140	Marked	.....	Died	Yes
Moorhead and Mc-Lester	1936	44 M	.....	Rt. and l. gastric	Severe	.....	.....	Died	Yes
Bruce <sup>14</sup> .....	1937	34 M	Abdominal pain	None definite	Normal	?	Yes	Recovered	
Bruce.....	1937	75 M	Abdominal pain	Mid-colic artery	Normal	.....	.....	.....	.....
Morton <sup>15</sup> .....	1938	72 M	Abdominal pain	Sup. mesenteric	155/96	?	Yes	Recovered	
Lafferty and Pearson <sup>16</sup>	1938	28 F	Shock; dyspnea	Sup. mesenteric	.....	.....	Yes	Recovered	
Silverstone <sup>17</sup> .....	1938	52 M	Abdominal pain	None definite	200 Systolic	?	Yes	Died	
Crile and Newell <sup>18</sup>	1940	49 M	Severe abdominal pain	None definite	260/130	?	Resection transverse colon	Recovered	
Berk, Rothchild, Doane <sup>19</sup>	1941	52 M	Dull abdominal pain	?	240/170	?	Yes	Recovered	
Cushman and Kilgore <sup>21</sup>	1941	40 M	Abdominal pain	Br. middle colic	Normal	?	Yes	Recovered	

TABLE I (Continued)

Author	Year	Age, Sex	Complaint	Site	Blood Pressure	Arterio- clevisis of Rup- tured Vessel	Opera- tion	Result	Autopsy
Cushman and Kilgore	1941	63 F	Severe abdominal pain	None definite	Normal	?	Yes	Recovered	
Doege and Gray <sup>21</sup>	1943	69 M	Abdominal pain	L. gastric artery	?	Present			
Doege and Gray....	1943	83 F	Abdominal pain and faintness	?	80/60	?	Yes	Recovered	
Hirsche <sup>22</sup> .....	1943	36 M	Epigastric pain	Gastroduodenal	240/140	?	No	Died	Yes
Haugen <sup>23</sup> .....	1944	55 M	Abdominal pain	Br. sup. mesenteric	?	No	Yes	Died	Yes
Marks and Freeland <sup>24</sup>	1945	55 M	Epigastric pain	None definite	84/70	?	Yes	Recovered	
Marks and Freeland	1945	43 M	Abdominal pain and vomiting	None definite	150/120	?	Yes	Recovered	
Marks and Freeland	1945	55 M	Vague abd. pain	None definite	245/142	?	No	Died	Yes
Tanna.....	1946	59 F	Severe abdominal pain	None definite	Normal	?	Yes	Died	Yes
Tanna.....	1946	35 M	Abdominal pain	None definite	Normal	?	Yes	Recovered	
Tanna.....	1946	M	Abdominal pain	Br. of splenic		?	Yes	Died	No

the patient under ethylene-ether inhalation anesthesia the abdomen was entered through a low, right paramedian incision. Immediately upon entering the abdomen, a copious quantity of bright red blood and blood clot was encountered. After rapidly evacuating the blood, exploration revealed a large, cystic mass immediately under the left leaf of the diaphragm. The incision was then extended upward and to the left, and the spleen delivered into the wound. It was found that there was a definite bleeding point from a vessel in the splenic pedicle. The cystic mass under the left leaf of the diaphragm proved to be a large hematoma which had collected there from the leak in the vessel of the splenic pedicle. The hematoma was evacuated, the spleen was removed and the abdomen closed in tiers utilizing retention sutures. The patient received blood continuously during the operative procedure. His blood pressure at the beginning of the operation was 180/110 and at the close 170/110. The patient left the operating room in fair condition.

During the first few hours postoperatively, the patient fared splendidly. At about 6:30 P.M. the day of operation, he took a sudden turn for the worse. He became dyspneic, pale and cyanotic, and his blood pressure fell steadily. In spite of blood, oxygen, and other supportive measures, the patient finally expired at 9:30 P.M. Permission for a postmortem examination could not be obtained.

#### COMMENT

An analysis of thirty-five cases of abdominal apoplexy, tabulated in the table, reveals some interesting points. The accident occurred much more frequently in males; twenty-five males to ten females, the ratio being 2.5 to 1. The ages varied from twenty-seven to eighty-three, but the average age was fifty-five and one-half years, with the greatest frequency of occurrence in the sixth decade of life.

Eighteen cases presented evidence of having a definite hypertension. Eight cases

are recorded as having a normal blood pressure, while two of the cases showed a definite hypotension which could have been due to a collapsed state due to blood loss at the time of examination. In the remainder, blood pressure recordings were not available. Thus, it is reasonable to assume that the majority of these patients suffered with cardiovascular disease.

In fifteen cases (approximately 42 per cent), it was specially noted that no definite bleeding point could be found. It is of interest that these cases occurred among the younger individuals of this group—the average age of this group being 46.5 years compared with 55.2 years in the group in which a definite bleeding vessel was found. In seven of the thirteen cases (53.8 per cent), the cardiovascular state was noted as being apparently normal. To state it in another way: Of the eight cases in which it was definitely noted that the cardiovascular state was apparently normal, there were six cases (75 per cent) in which no definite bleeding point could be found either at operation or at postmortem examination. This close relationship between a younger age occurrence, a relatively normal cardiovascular apparatus and the inability to demonstrate a bleeding point was noteworthy. The practical application of this relationship becomes apparent when the operative results are analyzed.

Twenty-eight of the thirty-five cases in this series (80 per cent) came to operation. Of these twenty-eight cases, twenty (71.4 per cent) recovered. Of the eight (28.6 per cent) in which operation resulted in death, five were cases in which no definite bleeding point could be found. From this, it would seem that, despite the occurrence of massive intraperitoneal hemorrhage, if at operation a definite bleeding point can be located and the bleeding vessel ligated, the chance of recovery is better than when the bleeding point cannot be located. Thus, it would appear that in this condition there might be some advantage favoring the hypertensive arteriosclerotic individual, in that such patients are much more likely to

present a definite bleeding point that would permit of ligation.

In only isolated cases is a diagnosis made prior to operation. While all cases were recognized as being acute abdominal emergencies, the majority were operated upon under a preoperative diagnosis of perforated peptic ulcer, intestinal obstruction, mesenteric thrombosis, perforated appendix, etc. A close analysis of the symptoms and signs in each of the reported cases reveals no one thing pathognomonic of the condition. It is to be emphasized, however, that any patient who is hypertensive and presents the picture of an acute condition of the abdomen along with a reduced erythrocyte level should be suspected of having this condition.

Moon<sup>25</sup> has called attention on many occasions to the significance of hemoconcentration as a diagnostic finding in true shock not due to hemorrhage. Repeated hematocrit readings will serve to differentiate between acute surgical abdominal catastrophes not associated with hemorrhage and abdominal apoplexy.

In spite of the fact that many in the past have assumed an indifferent attitude concerning abdominal puncture as an aid in diagnosis, Johnston<sup>26</sup> has shown that abdominal puncture, using a trocar 0.5 cm. in diameter, may be used with no danger of injury to the intra-abdominal viscera to confirm the diagnosis of hemoperitoneum.

It is believed generally that hypertension, severe gastrointestinal vascular sclerosis, separately or in combination, are decided factors in the precipitation of rupture of the vessel, comparable to cerebral hemorrhage in hypertension. Brooks,<sup>27</sup> in a study of 368 cases of arteriosclerosis, found in only nine macroscopic evidence which involved the celiac axis and its branches. This, unquestionably, explains the great infrequency of this condition.

#### CONCLUSIONS

1. Massive spontaneous intraperitoneal hemorrhage (abdominal apoplexy) resulting from the non-traumatic rupture of a

small, intra-abdominal blood vessel is a rare condition, the occurrence of which is being reported with greater frequency.

2. While there is no one pathognomonic finding, the conditions should be suspected in any individual in whom there occurs sudden severe abdominal pain, shock, signs of peritoneal irritation and a low hematocrit reading, especially if hypertension and/or arteriosclerosis co-exist.

3. Early operation, with ligation of the bleeding point if possible is the only treatment. This treatment is one which offers a high chance of recovery if a definite bleeding point be found.

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# CHRONIC BILATERAL BENIGN HYPERTROPHY OF THE MASSETER MUSCLES

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**M**EDICAL literature on this subject is very meager. In 1880, Legg<sup>1</sup> reported bilateral enlargements of both masseter and temporal muscles in a girl of ten years of age. The swellings developed about three weeks previously following an attack of feeling faint and vomiting. She received no treatment.

In 1905, Duroux<sup>2</sup> reported bilateral hypertrophy of the masseter muscles in a young man of twenty-two. The swellings had been present for less than two months. No treatment is mentioned.

In 1930, Boldt<sup>3</sup> published a thesis on simple masseter hypertrophy. He mentions several unilateral involvements and one bilateral hypertrophy in a man of twenty-three in whom there was a "psychic reaction which was the cause of the constant trismus and the noticeable masseter hypertrophy."

Although the etiology of simple muscle hypertrophy is not clear, there is a strong suspicion that the patient's habit of grating his teeth might be closely related to the muscle swellings in the case herein reported.

## CASE REPORT

Mr. C. H. S., a single, thirty-five-year-old shipyard worker was first seen on October 25, 1944. He complained of a painless swelling just above the angle of each jaw. The swellings had been present for about twenty years, and although they had produced no subjective symptoms they were unsightly and the patient was becoming increasingly annoyed by their presence. He was interested in having them removed. There was nothing unusual in his family history. The patient himself was of temperate habits. His only mannerism which might be related to his condition was a habit

of grating his teeth since he was "somewhat nervous." Although no previous treatment had been instituted, tissue for microscopic examination was removed from the left side by another physician (Dr. R. H. S.) a year previously. The pathologist reported "normal muscle tissue."

Examination disclosed a bilateral, smooth, dome-shaped, painless, rather soft subcutaneous tumor just in front of and above the angle of the mandible. (Fig. 1.) The left side was slightly larger. With the jaws tightly closed the masses became more prominent and quite firm to palpation. Each tumor mass measured about 40.0 by 40.0 mm., and projected from the normal surface level of the skin by about 6.0 to 7.0 mm. The overlying skin was normal in appearance and could be moved freely over the masses. No regional lymph nodes were palpable. The usual laboratory tests were within normal limits and the serology was negative. No other muscle hypertrophy was noticed elsewhere on the patient. The jaw had a normal range of motion.

On the basis of his history, the physical findings, and the report of the previous biopsy, a diagnosis of chronic, bilateral, benign hypertrophy of the masseter muscle was made. Since the appearance of these swellings was very disturbing to the patient, their surgical removal was advised.

On January 25, 1945, under local anesthesia (novocain 1 per cent) a curved incision about 8.0 cm. long was made over the angle of the jaw, its concavity facing upward and forward. The incision was carried through the skin and subcutaneous fat down to the fascia covering the masseter muscle. The flap thus created was retracted upward and forward thereby producing an adequate exposure. Care was taken to avoid damage to the parotid gland. The fascia overlying the masseter muscle was very thin. The tumor mass appeared to consist entirely of masseter muscle fibers which bulged forward into the field. The fibers appeared to herniate



FIG. 1. Showing patient before surgery; jaws relaxed.



FIG. 3. Patient three months after surgical removal of hypertrophied muscle.

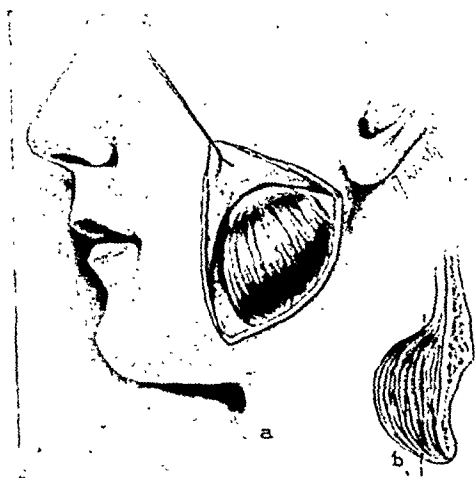


FIG. 2. Drawing.

as though through an opening, although nothing suggesting an opening or ring was found. The masseter aponeurosis could be identified in the upper part of the wound as it disappeared upwards beneath the flap. Immediately below this the muscle was thick and fleshy throughout its entire width. (Fig. 2A.)

Correction of the deformity consisted of excising that portion of the muscle which bulged outward and seemed to be in excess. The excision extended from the aponeurosis above to the lower border of the mandible and

included the full width of muscle. About one-fourth to one-third of the fibers were permitted to remain intact. (Fig. 2B.) Bleeders were tied with No. 00000 plain catgut and the skin was closed with fine silk. No drains were used and a pressure dressing was applied. The same procedure was carried out on the opposite side.

The patient made an uneventful recovery and left the hospital on the sixth postoperative day. He has been followed for about a year with no evidence of further trouble. He states he can chew as well as ever and no perceptible change can be noticed in his biting power. (Fig. 3.)

The pathologist's report is as follows: Gross: "Specimen received consists of two separately labelled specimens removed from the left and right cheeks. The specimen from the left cheek is labeled No. 1 and consists of one good sized block of muscle and another smaller mass of fibrous and fatty tissue which contains some hard, dark brownish-black nodules, the largest of which measures 1 cm. in dimension. The main mass of muscle measures 5.5 by 3.0 by 1.0 cm. On section there is nothing grossly remarkable about the muscular tissue. Sections are taken both longitudinally and in cross section. The nodular mass in the soft tissues on section is recognized as freshly clotted blood. The second specimen consists of another good-sized mass of muscular tissue with two other

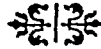
smaller masses of fatty tissue admixed with muscle. The main tissue measures 4.5 by 3.0 by 1.0 cm."

Microscopic: "Cross section of the portions of muscle reveal the bundles to be very compact and the muscle fibers to be very tightly contiguous with each other. In longitudinal section the same characteristics are noted. The fibers, however, stain rather poorly but there is no evidence of any inflammatory process here present. Some edema fluid is accumulated between the larger bundles of muscle fibers and

other than for these changes I am unable to recognize anything further."

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## BOOK REVIEW

**S**CIENTIFIC, Medical, and Technical Books,\* an eleven hundred page book, prepared under the auspices of the National Research Council, presents a selected list of titles in print with annotations. Librarians, teachers, scholars and professional technical workers in the fields covered as well as those engaged in the distribution of books will find it particularly valuable.

It is interesting to note that over 6,000 titles of selected works of merit by American authors have been included by the committee. Books out of print have not been omitted. All in all the committee has done a laborious job extremely well.

\* Scientific Medical, and Technical Books (Published in the United States of America 1930-1944). Edited by the R. R. Hawkins. Washington, 1946. The National Research Council.

*ANNOUNCEMENT: Urology Award*—The American Urological Association offers an annual award not to exceed \$500 for an essay (or essays) on the result of some clinical or laboratory research in Urology. Competition shall be limited to urologists who have been in such specific practice for not more than five years and to residents in urology in recognized hospitals.

For full particulars write the Secretary, Dr. Thomas D. Moore, 899 Madison Avenue, Memphis, Tennessee. Essays must be in his hands before May 1, 1947.

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## Editorial

PRESIDENTIAL ADDRESS

### ACTIVITIES OF A SERVICE COMMAND SURGICAL CONSULTANT

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PRESIDENTIAL addresses are yearly occurrences in most societies which are imposed upon the retiring president without regard to subject matter or, in fact, whether the president has anything to say. The choice of subject is wide and is usually devoted to the expostulation of a fundamental principle, a review of events past or a prophetic analysis of the future. Not wishing to stray too far afield, I shall try to touch upon all of these matters.

In a peacetime setting this organization was founded in 1938 for the purpose of maintaining high standards for the care of the injured. In terms of accomplishment we have matured rapidly. Within less than four years after that date, of our membership, fifty-one to be exact, volunteered their services. Medicine in war is largely surgery of trauma and the society was well fitted to make a major contribution.

There is not time to recount all the contributions made by members of this society during the war. In war, no less than peace, this society has, through its membership, taken a place of leadership. I can best speak regarding the place of the Service Command Surgical Consultant because it was from the vantage point supplied

by this position, that it was my privilege to view the results of our peacetime efforts in regard to the establishment of sound principles of care of the injured and the effects of the training afforded young surgeons.

The Consultant Service of the Army was first set up in World War I, but augmented and more completely developed and coordinated in World War II under the Consultant Division of the Surgeon General's Office. This professional service was authorized by the War Department in June, 1942, to serve not only theatres of war but also the nine Corps Areas, later designated as Service Commands in the Zone of the Interior.

The purpose of the Consultant Service was intended to be constructive and every attempt was made to fulfill this ideal.

In the Theatres and Service Commands, medical officers assigned as consultants by the Surgeon General were selected to cover the fields of Medicine, to include the medical specialties (except neuropsychiatry) venereal disease, dermatology, dietetics and clinical pathology: Surgery, all surgical specialties, general, orthopedic, urological, gynecological and obstetrical, ophthalmological, otorhinolaryngological, radiological and physiotherapy and a third consultant in neuropsychiatry to include neurology, psychiatry and war neuroses. A consultant in orthopedic surgery was later added to the group to serve with the consultants already on duty, who functioned as professional advisers to the command surgeons. In addition to selecting medical officers assigned to duty, another constructive innovation was developed by the Surgeon General, in recommending to the Secretary of War, that designated civilian physicians and surgeons be assigned on a temporary duty status to visit the respective special services in named general, regional and some station hospitals. This special group of civilian consultants in surgery visited and reported on orthopedic surgery, neurosurgery and plastic surgery. The contributions made by these surgeons were constructive and most important, with the officers at all installations giving unanimous favorable expression to this additional consultation service.

Late in 1944, key officer personnel assigned to Regional hospitals were named "sub-consultants" to visit the designated satellite station hospitals in the respective geographical areas. This arrangement made possible more frequent professional visits to the satellite hospitals and relieved the consultants at a time when the general

hospitals were receiving more battle casualties and most of the Z. I. major surgery was being concentrated in the Regional Hospitals.

The War Department has recently authorized the continuance of the Professional Consultants in W. D. Circular 101, dated April 4, 1946, which reads as follows: "In order to insure the maintenance of the highest professional standards and to provide close liaison with leaders in the medical profession at large, a system of utilizing professional consultants developed by the Surgeon General during World War II will be continued and extended in the future. Consultants in internal medicine, surgery, neuropsychiatry, preventive medicine, dentistry, veterinary medicine and other special medical fields, will be designated by the Surgeon General."

The relationship of the surgical consultant with the consultants in medicine and psychiatry was most cordial; in addition, this association was constructive and educational. The common objective in this assignment provided the opportunity for a free exchange of ideas relative to duty personnel and other matters pertaining to policies which the surgeon of the command would wish to have us follow up in the field.

The medical officers assigned to duty in hospitals, with field units, induction stations, reception centers, dispensaries and various other army installations came from all sections of the country with divergent viewpoints and varying types and degrees of training. It became one of the responsibilities of the consultant to assist the surgeon of the command and the officer at headquarters, assigned in charge of professional service, to evaluate the professional qualifications of the medical personnel in the respective branch of medicine and assist in placing officers in positions consistent with their ability and training in not only fixed installations but over seas units as well. In addition the appraisal of therapeutic and diagnostic procedures and agents and the coordination of professional practice by local discussion with hospital staffs of such professional and administrative problems as may have presented themselves.

The activities of the surgical consultants in the various commands were not governed by an outlined program, as no pattern was set up by the Consultant Division of the Surgeon General's Office. It was, however, understood that encouragement would be given by the consultant to the commanding officer and staffs of the respective hospitals, to maintain the high standard of surgery practiced in the modern well organized civilian teaching hospital. Inas-

much as there was no set pattern for the consultant's activity, as applied to the surgical services, the continued spirit of cordiality and cooperation shown by the Surgeon General's Office, the associated officers at Headquarters and those in the field helped materially to carry through the concepts of this additional Medical Corps service.

The objectives of the surgical consultant as described by Colonel Bradley Coley,<sup>1</sup> the first Surgical Consultant of the Eighth Service Command, "are varied but they all have but a single purpose—to provide the best possible care of the sick or wounded soldier. All other aims are subordinate." It was the policy of the Seventh Service Command to carry out these objectives, by having the consultant make and maintain a close relationship with the services of the Medical installations in the command. This was accomplished by developing an understanding with the chief of the surgical service of each hospital to correlate the various sections with the service as a whole, in addition to the respective services with one another; also providing as it was possible, an even distribution of qualified specialists; encourage and by personal interview advise officers of their responsibility in maintaining the highest standard of professional care, by continuing the post graduate educational programs, as have been so well developed in our teaching institutions. Coley further stated, "there is a general agreement among us—that the standard of professional care is no better than the educational level of it's medical officers."

The following represents some of the features of the professional training program: (1) Section ward rounds with discussion of cases; (2) weekly clinicopathological conferences; (3) weekly meetings of the major services; (4) monthly staff meetings; (5) seminars when current medical literature was presented and discussed and (6) invitations to nationally known physicians and surgeons under the auspices of the War-time Graduate Medical program. The invited guests made ward rounds, held clinics, gave demonstrations, discussed some subject in their field, etc.

It was stimulating to observe in most of the hospitals the enthusiasm and interest manifested by the officers in their participation and adhering to this type of post graduate training, encouraged by the Surgeon General. This pattern of post graduate training could well be integrated in the educational programs of civilian hospitals, except for the many extracurricular activities and responsibilities that may be placed on staff members.

This presentation pertains to some of the activities in the Seventh Service Command, where it was my privilege and pleasure to serve as the surgical consultant for a period of forty-four months. This command covers the area east and west between the Mississippi River and the Rocky Mountains and from north to south, the Canadian border to Arkansas and includes nine states as follows: Missouri, Kansas, Iowa, Nebraska, South and North Dakota, Minnesota, Colorado and Wyoming. The major activities were carried out principally in the field, with travel chiefly by rail or automobile and later by military airplane, visiting both the Army Service Force and Army Air Force Installations, which included four general and fifty-eight station hospitals, with one of the latter at Camp Carson, subsequently being designated as a general hospital, a part of a Hospital Center along with the Convalescent Hospital. The breakdown of the station hospitals represents sixteen A.S.F., thirty-two A.A.F. and ten prisoner of war camps. Eight of the Station hospitals were later designated as Regional hospitals, four A.S.F. and four A.A.F. The total troops in the command at the end of the respective years 1942, through 1945, with the total beds provided and patients hospitalized are reported as follows:

Year	Troops	Beds	Patients
1942	200,000	18,700	14,900
1943	439,000	32,100	16,575
1944	371,000	30,000	13,500
1945	285,000	24,835	13,450

The objectives of the consultant in the field have already been referred to with the evaluation and supervision of professional services emphasized as number one. To this end when visiting the hospitals most of the patients on the surgical services were presented on ward rounds in the respective sections.

Informal discussion often developed with special or selected cases, relative to not only the diagnosis and treatment, but the disposition of the patient as well, inasmuch as it became one of the consultant's responsibilities to urge prompt disposition of patients to maintain a low non-effective rate. The clinical activity afforded the consultant an opportunity to evaluate the results of the superior educational programs carried on in the medical schools, combined with the advanced interne and resident training in the hospitals. With few exceptions this was apparent at most hospitals, as was manifested

in the approach made by the officers in arriving at a diagnosis, particularly in problem cases; the over-all understanding and the subsequent surgical management. This contact with the officers on ward rounds provided an opportunity for a free exchange of ideas, in addition to bringing into the open, facts relative to individual problems, if they existed. This method of approach also provided discussion relative to methods of treatment as outlined in army regulations and circulars, without interfering or upsetting too much, the thinking and initiative of the officers. On the contrary from observations, it was apparent that this relationship with the consultant added to the officers security, improved his morale and no doubt created a personal reaction that his chief of service and others were interested in his ward activities and contribution. It can be said that the consultant has benefited professionally many times as a result of his experiences.

In addition to the ward activity and conferences, an informal meeting was usually held with the officers at which time some subject was presented for discussion or the consultant's participation would be limited to a discussion of some subject presented by a duty officer.

Included in the request of the Surgeon General to the War Department for the Consultant Service, it was stipulated that the officers assigned as consultants serve in an inspectorial and consultative capacity and each consultant render a written report, concerning his activities at each facility visited. A detail report of each visit was therefore forwarded as follows: ASF installations, Consultant to Station Surgeon, Service Command Surgeon and Surgeon General; AAF installations—Consultant to Station Surgeon for such disposition as was indicated by AAF authority, which was to the Commanding General, Army Air Forces, Attention: The Air Surgeon. The inspections of the surgical services were reported under the following headings:

1. Authority for inspection.
2. *Hospital*—with consideration of the general set-up, bed capacity (normal and possible expansion) census, alterations or new construction, problems, policies, etc.
3. *Personnel*—officers assigned, numerical and professional adequacy.
4. *Training* to cover the professional and technical programs, as well as the conferences, section and staff meetings.

5. *Surgical service*—to include a description of the over-all set up, patient load of the respective sections, cases presented and discussed on ward rounds in each section and consideration of problems pertaining to the service.

6. *X-ray*—types and adequacy of the equipment, work load and personnel assigned to include trainees.

7. *Operating Room*—equipment which in the early period of the war was limited and inadequate, but later complete. Types of anesthetic administered, complications if any, the work load per month, personnel assigned and the training program for enlisted men and WAC'S.

8. *Physiotherapy*—equipment installed, personnel assigned, work load and training program in force.

9. *Case discussion* with reference to this activity in the wards and special cases requiring consultation.

10. *Disposition Boards*—the number of meetings held, the type of cases reviewed and promptness of disposition.

11. *Records*—these were universally found to be complete.

12. *Library*—a good variety of bound text books were found available with additions made on request, as were the medical journals, representing the specialties.

13. *Nurses*.

14. *Enlisted Personnel*—the number assigned, the specific training programs conducted for the technicians, orientation lectures and demonstrations and the form of rotation in the various sections.

15. *WAC'S* assigned and their training program.

16. *Summary* and evaluation of the professional service.

The variety of surgical conditions observed and examined in the respective General, Regional and Station hospitals over the period of months, can be divided into two groups as follows: (1) Conditions seen during the training period, to include those which would commonly be seen in comparatively young adults, in addition to accidents and injuries sustained while either on or off duty, and (2) combat injuries returned to the Zone of the Interior from the various Theatres of War.

The first group would include the various types of hernias, gall-bladder and thyroid disease, appendicitis, infected pilonidal cysts, varicose veins, rectal lesions and such orthopedic conditions as dislocated knee cartilages, foot disabilities, recurrent shoulder dislocations and impaired function of extremities, complicating old



fractures and dislocations. Added to this category of surgical conditions depending on the type of training program, were many types of fractures, sprains, accidental gunshot wounds, injuries such as to require immediate or subsequent amputations, burns although the severe type were comparatively infrequent with many burns, however, of a lethal nature reported and seen following airplane crashes. The variety of fractures also observed at Air Force hospitals were often of a severe type.

The combat injuries admitted to the General hospitals were screened at the ports of debarkation and then assigned by the Surgeon General's Office to the hospital designated to receive the special types of cases where specialists in the respective fields were on duty. The general hospitals in the Seventh Service Command designated to receive the special cases were as follows: Neurosurgery, plastic maxillofacial and ophthalmic surgery, O'Reilly General Hospital at Springfield, Missouri; early and for several months when combat injuries were being returned to this country Schick General Hospital at Clinton, Iowa, was designated to receive neurosurgical cases; chest surgery, Fitzsimons General at Denver; trench foot, Camp Carson General at Colorado Springs, Colorado and orthopedic surgical cases distributed to all general hospitals with comparatively large services at Fitzsimons, O'Reilly, Schick, Winter at Topeka, Kansas and Camp Carson. The general surgical cases were also distributed to the General Hospitals. Many of the combat injuries returned to the Z.I. arrived in such a condition as to indicate that the surgical and medical care given at the front and subsequently, had been of a superior type and the morale of the sick or wounded soldier excellent. The surgical problems, which presented themselves in the vast majority of cases were numerous and in many instances both the ingenuity and skill of the officers were taxed to the limit.

The high caliber of surgical care reflects the background and training of our medical officers. While the caliber of surgeons in the field could be readily surmised by the results observed, and statistics relating to our casualties, the activities of the Service Command Consultant brought him in direct contact with the products of our peacetime training program and the results of their activities. The Consultant Service has been recognized as having been largely responsible for assignment of men where they were best suited. The fact that there were well trained men available made the consultant's program more effective.

This society has reached the vigor of young maturity. It has been tried in the fire of war and has proven its worth. It is our obligation to continue in the progressive spirit of our youth as a society. The combat activities are over, but there are still challenging problems before us. Medical aspects of preparedness require that we continue to maintain high standards of training in our residency programs, to continue our interest in the service in order to improve the organization of the medical departments of the army and the navy, and to continue to develop and test fundamental concepts relating to the care of the injured.

I have been honored by having been elected your president. As past president I pledge to continue my interest and activities toward those principles which have permitted our organization to have made the kind of contribution it has in the past eight years.

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# Original Articles

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## AN ADJUSTABLE INTERNAL FIXATION ELEMENT FOR THE HIP\*

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RIGID and accurately fitted internal fixation making possible a maintenance of local and general physiology during the healing period is the therapy of choice for fractures at the hip and for the management of certain reconstructions of the upper femur. The mechanical problem of such fixation usually requires that the proximal fragment be held in the desired relationships to the femoral shaft rather than *vice versa*. This is accomplished in intertrochanteric, pertrochanteric and subtrochanteric fractures and in high osteotomies by mechanically fastening the proximal fragment or fragments to the solid cortical bone of the subtrochanteric region. The fixation is carried out by various single or double unit devices, the proximal component of which is driven through the trochanter into the substance of the femoral neck and head while the distal is fixed to the femoral shaft by screws. The available devices all are characterized by certain common defects which make the technic of their application unnecessarily difficult and the resultant fixation potentially insecure.

All have a fixed angle between their component elements. By use of bending irons it is possible to change this angle prior to insertion into the bone. Estimation of the desired angle prior to actual application of a device to the lesion requiring fixation cannot be exact and rarely is accurate. Seldom has it been found possible to adjust the angle accurately enough to make the apparatus fit the femur exactly. Invariably it has been necessary to change the position of the femoral shaft to conform with that of the plate in order

\* From the Fracture Service of the Presbyterian Hospital in New York and the Department of Surgery, the College of Physicians and Surgeons, Columbia University.

to obtain exact apposition of their surfaces. A small change in position of the femoral shaft may be anatomically insignificant, but from the viewpoint of fixation it may result in an abnormal degree and distribution of strain upon both the apparatus and the bone fragments. Abnormal or unevenly distributed strain always creates a potential risk of loss of position and is the major cause of breakage and loosening of internal fixation.

Single unit devices fail to provide an adequate choice of nail or blade length. Consequently, in the course of an operative procedure, the available length best suited to the purpose at hand is used. Often this length proves a little longer or shorter than the ideal. If it is too short, there is danger that it may pull out of the proximal fragment and result in loss of fixation. If it is too long, subsequent collapse of fractured cancellous bone during the healing period may result in protrusion into the acetabulum.

Single unit devices all are characterized by another common defect frequently necessitating a compromise with the principles of adequate internal fixation. Unless the device is inserted into the trochanter in exactly the correct plane the plate protrudes from the proximal fragment in a direction that is either flexed or extended in relation to the desired axis of the femoral shaft. The only recourse is to withdraw and reinsert the apparatus or change the axis of the femoral shaft to conform with that of the plate. The latter is accompanied by the potential risks of abnormal and unevenly distributed strain jeopardizing the security of the fixation. The insecurity of fixation following withdrawal and reinsertion of a nail or blade requires no comment.

Experience and adequate operative technic tend to minimize the significance of these defects. However, the necessity for avoiding their penalties makes the operative procedure more difficult than need be. In addition, the impossibility of neutralizing completely the common defects outlined necessitates frequent minor and at times major compromises with the principles of internal fixation that could not be tolerated elsewhere in the bony system. This criticism of the ingenious devices in common usage is not meant to be destructive. The defects outlined serve but to emphasize the ideal requirements experience indicates to be desirable in any apparatus used for internal fixation of bony lesions involving the cancellous portion of the upper femur.

Such an apparatus should have an angle between its two component elements sufficiently adjustable in both planes to allow of

apposition of plate to femoral shaft regardless of the axis of the bone and regardless of unavoidable minor directional errors in the insertion of the nail. A three-flanged nail is considered to provide more secure fixation than a blade, but there should be available a complete freedom of choice in the matter of nail length. The mechanics of locking nail and plate together in any desired position must be simple and secure. Once fastened to the bone the apparatus must provide rigid fixation sufficient to permit maintenance of local and general function except for weight bearing by the extremity involved.

The advantages of an apparatus answering these requirements have been appreciated for many years. During the past few years the Fracture Service at the Presbyterian Hospital in New York has attempted to develop an instrument that would meet these specifications. The constant aid and cooperation of the Austenal Laboratories Inc. is acknowledged with gratitude. The Vitallium instrument to be described is by no means perfect, but its use in the management of intertrochanteric fractures and high femoral osteotomies to date has demonstrated great advantages over the fixed angle devices previously used for fixation of these conditions.

The proximal component of the instrument consists of a cannulated Smith-Petersen nail, the ordinary flat-surfaced head of which has been modified and fashioned into the shape of a hemisphere. The distal component is a plate which is not extraordinary except for its proximal end which is also fashioned into the shape of a hemisphere. The curve of the hemispherical nail head is identical with that of the plate. Exact apposition of nail head to the curved portion of the plate is assured at any angle between  $120^{\circ}$  and  $160^{\circ}$ . (Fig. 1.) Maintenance of apposition between nail head and plate is obtained by a heavy set screw passing through the plate to engage five full threads in the head of the nail. Variations in the angle between the nail and the plate are made possible by the fact that the set screw passes through a longitudinal slot in the curved upper portion of the plate instead of through a round hole. (Fig. 2.) The set screw can be slid up or down this slot to change the angle between nail and plate. The apposing hemispherical surfaces of the nail head and the curved portion of plate are knurled so that the points and crevices of the two knurled surfaces reciprocate with each other. Final tightening of the set screw, regardless of the relationship of nail to plate, locks the reciprocating surfaces firmly together. Similar adjustment of the axis of the plate in relation to

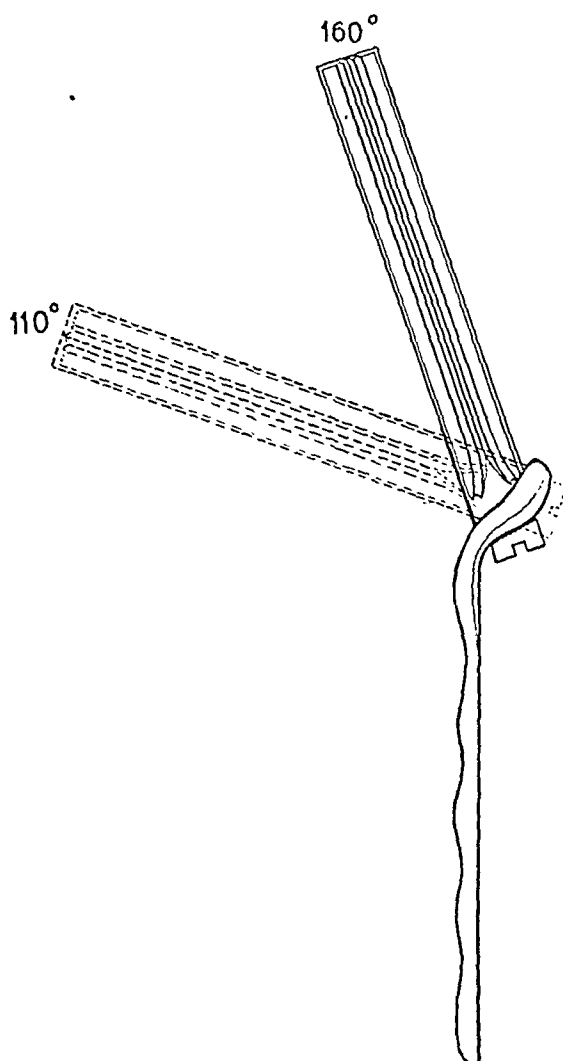


FIG. 1. Side view drawing of the adjustable hip fixation instrument. The nail and plate may be locked together at any angle between 110 and 160 degrees.

that of the inserted nail in the coronal plane is also possible. It may be rotated around the center of axis formed by the set screw through a full  $360^{\circ}$ . (Fig. 3.) Gradations in length of the nails kept on hand makes possible the use of one which corresponds to the estimated length required. The nails may be used in the ordinary manner without the plate so that maintenance of all lengths in stock does not constitute wastage from the viewpoint of operating room inventories. Plates of five and seven inches in length have been used and one or the other usually is appropriate for the average fixation problem to be encountered.

This instrument has been used in both closed or lateral nailing

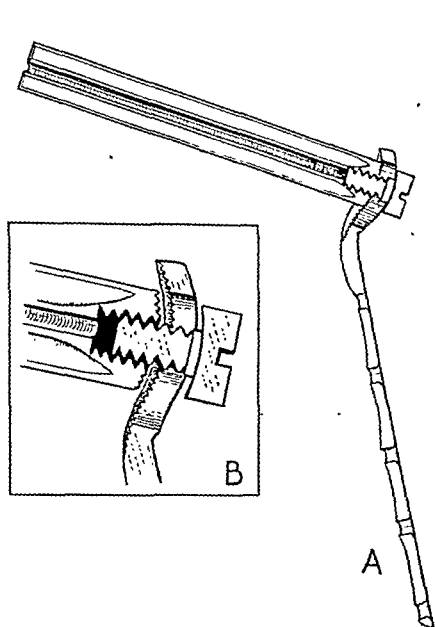


FIG. 2.

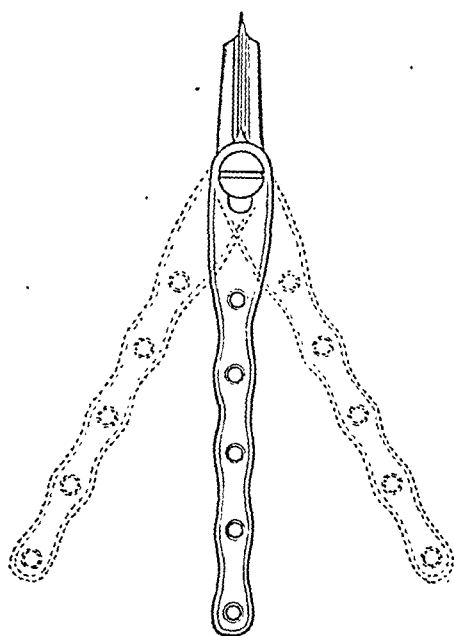


FIG. 3.

FIG. 2. Side view of the adjustable instrument in cross section. A, nail and plate are fastened together by a heavy set screw passing through a slot in the curved upper portion of the plate to engage five full threads in the head of the nail. B, inset shows an enlarged drawing of the locking mechanism. The apposing hemispherical surfaces of nail and plate are burred in such a way as to assure reciprocation, regardless of variations in the angle between the two. Tightening of the set screw locks these reciprocal surfaces together in the desired position.

FIG. 3. Front view of the instrument. The plate may be rotated around the center of axis formed by the set screw to conform to variations in flexion or extension of the femoral shaft.

procedures and open reductions. The general policy of our service at the present time is to fix by the extra-articular method only undisplaced fractures or those impacted fractures characterized by a relatively horizontal fracture line and a valgus position of the proximal fragment. This policy is adhered to currently as a result of a thorough clinical trial and study of the end results of both methods. The properties of the adjustable nail plate have proved to be particularly useful in extra-articular fixation procedures. Regardless of minor directional errors in the axis of the inserted nail a flush apposition of nail head to plate coincident with exact apposition of the plate to the femoral shaft has been possible without disturbing the impacted or undisplaced fracture by mobilization of the femoral shaft in an effort to make it fit the plate.

Displaced fractures are subjected to open reduction and the insertion of fixation under direct vision. Exposure of the hip through

the interval between the tensor fascia femoris and the lesser glutei is best suited to the use of adjustable fixation. It is important that the fascial incision be made through the superficial and deep sheaths of the tensor separately rather than through the fusion of the two behind the posterior border of the muscle. If the interval between tensor and lesser glutei is entered by a single incision through the fused fascial layers posterior to the tensor the gluteus maximus is allowed to fall backwards and a large subgluteal dead space is created. This dead space is difficult to obliterate and frequently becomes the site of a large haematoma postoperatively. A considerable number of the hip disasters to be encountered following open reduction done through the lateral approach result primarily from infection of a haematoma within this dead space.

The superficial fascial sheath over the tensor is incised longitudinally over the whole length of the muscle. At the insertion of the muscle the incision is inclined slightly backwards to split the fascia lata parallel to and just behind to the ileotibial band. Continuity of muscle belly and ileotibial band is thereby undisturbed and both structures may be retracted as a unit if the fascial incision is of adequate length. The tensor belly is shelled forwards out of its fascial encasement leaving the deep fascial sheath temporarily intact. This sheath is incised longitudinally over the hip joint capsule close to its anterior point of fusion with the superficial sheath. The anterior segments of both sheaths are retracted forwards along with the tensor and ileotibial band. The posterior segment of the deep sheath remains in relatively normal position by reason of intact attachments to the lesser gluteal fascia and other neighboring structures and acts as a sling to suspend the gluteus maximus in normal position.

Adherence to this technic does not embarrass exposure of the hip and it does eliminate the danger of creating a dead space deep to the gluteus maximus. In addition, fascial closure at the end of the procedure is greatly facilitated and may be accomplished without appreciable tension. Snug closure of the fascia without tension is particularly desirable when adjustable fixation is used. It is obvious that the curved portion of the plate and the head of the set screw produce a metallic bump on the lateral aspect of the femur. The present model of the instrument does not produce a large bump and previous models characterized by much more prominent projections caused no subjective symptoms even though the projection was easily palpable. (Fig. 4.) However, the presence of a metallic mass





FIG. 4. Previous model of adjustable hip fixation having a much more marked metallic projection from the side of the femur. A and B, fixation of intertrochanteric fracture. C, vertical fracture through neck of femur, three months' duration. D, open reduction and fixation by nail, supplemented by a high osteotomy designed to produce a more horizontal fracture line.

on the side of the femur warrants all preventive measures possible against postoperative diastasis between the tensor and the gluteus maximus.

The nail is inserted over a guide wire or not depending upon local circumstances and the individual leanings of the surgeon. Great care should be taken to make sure that it is not inserted too far. It is obvious that if the nail is driven into the femur until its head is flush with the lateral surface of the bone application of the plate to the shaft of the femur will leave a gap between the nail

head and the curved portion of the plate. It then becomes necessary to withdraw the nail a short distance before it can be apposed and locked to the plate. Withdrawal of a nail after it once has been inserted is quite difficult in certain intertrochanteric fractures, and withdrawal, even if only a few mm., invariably reduces the efficiency of its hold upon the proximal fragment to make the fixation potentially insecure. To guard against this eventuality insertion of the nail should be stopped while it still projects at least two centimetres from the bone. The plate is then attached to the nail head at an angle conforming to that of the femoral shaft. The set screw is tightened and the remainder of the insertion is carried out by hammering directly upon the head of the set screw which is constructed sturdily enough to withstand such treatment. Adherence to this technic precludes the possibility of driving the nail into the bone so far that it cannot be locked to the curved portion of the plate.

Following insertion of the nail to the point where the flat portion of the plate abuts against the side of the femur the set screw is loosened. Final adjustment of the position of the plate to conform with that of the femoral shaft is carried out and the set screw again tightened, this time as firmly as possible. The plate is fixed to the femoral shaft by screws, all of which should engage both cortices of the bone. The final tightening of the set screw is of great importance and may result in faulty fixation if carelessly done. The knurled surfaces of nail head and plate reciprocate with each other. Tightening of the set screw alone may compress these two surfaces together point to point rather than in a reciprocal manner. Therefore, after firm tightening of the set screw it is advisable to tap the curved portion of the plate briskly a few times in order to jar the reciprocating surfaces into place and then re-tighten as strongly as possible.

Certain comminuted fractures through the cancellous bone of the upper femur are characterized by a tendency to collapse and shorten during the healing period. Such a collapse cannot be prevented except by long-continued traction. For this reason, in contradistinction to fractures of the femoral neck, a long nail should not be used for the fixation of intertrochanteric fractures. The point of the nail should not penetrate closer than 1.5 cm. to the acetabulum. If it is inserted farther than this bony collapse may result in its penetration through the femoral head into the joint since the attached plate prevents any backing out of the nail. The nail length



FIG. 5. Roentgenogram illustrating the use of adjustable internal fixation for intertrochanteric fracture.

of choice for use with the adjustable plate is that which is estimated will penetrate the full length of the neck but which will not pass the mid-point of the femoral head. (Fig. 5.) High osteotomies carried out as a primary procedure for vertical subcapital fractures or as a reconstruction measure should be preceded by insertion of the nail. In the former, open reduction and nailing under direct vision is done in the routine fashion with one important exception. Rather than a long nail, begun several inches below the oblique line and inserted up through the neck and head as nearly vertical as possible, a short and fairly horizontal nail entering the femur at or just distal to the oblique line is inserted through the reduced fracture. The plate is fastened to the nail and locked in a position corresponding to that which it is estimated will be optimum for the shaft of the reconstructed bone. The presence of the plate projecting from the nail head in the desired axis facilitates estimation of the various angles necessary to the accomplishment of the osteotomy. Wedge oste-

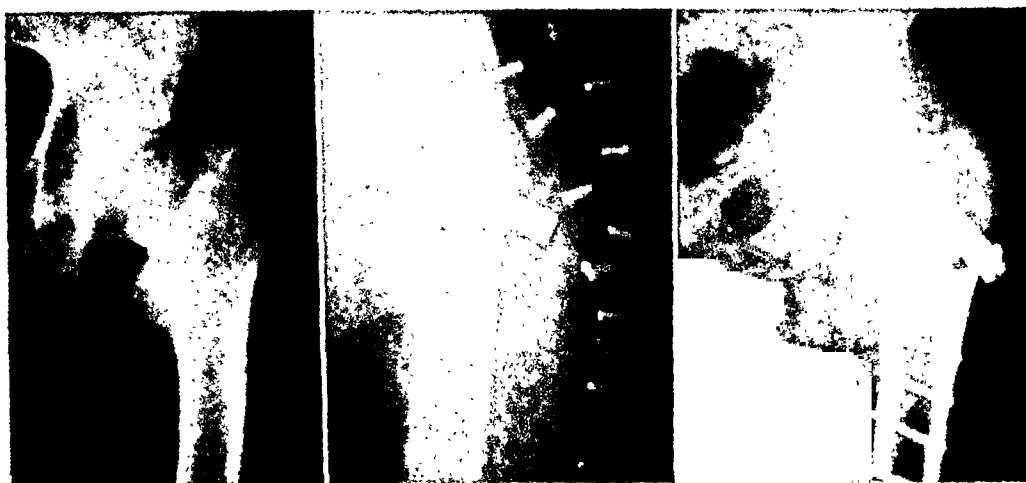


FIG. 6. Roentgenograms illustrating the use of adjustable fixation for vertical subcapital fracture of the femoral neck. Open reduction and fixation by nail is supplemented by a high wedge osteotomy which is fixed by the adjustable plate.

otomies permit the most accurate reposition and rigid fixation of the reconstructed bone. An appropriate wedge of bone is removed from the femoral shaft just distal to the head of the nail. Fixation becomes a simple matter since minor errors of angle in doing the osteotomy are compensated for by the adjustability of the plate. Apposition of the osteotomized surfaces coincident with rigid internal fixation is accomplished with ease. (Fig. 6.)

The adjustable nature of the apparatus makes it potentially useful in certain femoral neck fractures. Insertion of a nail for fixation of a femoral neck fracture occasionally is accompanied by a splitting of the lateral femoral cortex. At times this results in actual insecurity of fixation. The availability of an adjustable plate which may be used to anchor the head of the nail to the lateral femoral cortex, regardless of the axis of insertion of the nail, presents definite advantages under such circumstances.

The instrument described has been utilized for the fixation of a small series of intertrochanteric fractures and high femoral osteotomies. The potential disadvantage of the metallic bulge on the lateral surface of the femur has been scrutinized carefully in every case. Actually the prominence is no more marked than that produced by a Smith-Petersen nail alone if 1.5 to 2 cm. are left projecting from the bone. It has been palpable in thin patients but has produced no subjective symptoms in any case. The holding power of the adjustable device over the period required for fracture healing has proved adequate. No change in the relationship of nail to plate has occurred in any case. Operative technic has

been simplified by the adjustability of the instrument, providing care is taken to prevent too deep an insertion of the nail and incomplete locking of the reciprocating surfaces of nail and plate.

#### CONCLUSION

Rigid fixation of intertrochanteric fractures and high femoral osteotomies is possible by an internal fixation instrument which is adjustable to the position of the bone fragments.

#### DISCUSSION

HENRY C. MARBLE (Boston): I am interested in Dr. McLaughlin's paper. There is no question that we made material advance when a three-flange nail was produced that would fix fractures of the neck of the femur.

There is one point in his discussion of this problem which is in his paper but which he did not emphasize, which is important and that is that they found in intracapsular fractures the necessity more and more of visualizing the reduction. In other words, less blind nailing and more open nailing.

We are often deceived by x-rays. It has been my experience that the deception is in the form of x-ray understating the case rather than overstating it. The fracture that you find, as they have shown in their experience, is worse when it is exposed than it is in the x-ray picture. In the intertrochanteric fractures it is often desirable to get fixation. The apparatus we have had in the past has been hampered by the fact that you must bend or correct the plate that holds the screw firmly in place. Dr. McLaughlin has presented us with what seems to me such an obvious solution of a plate which can be attached to the three-flange nail at any angle and adjusted to hold it firmly in place and give that fixation.

Again I want to say in intertrochanteric fractures it has been my experience that the extent of bone damage which lends itself to nailing is often greater than when anticipated from the x-ray pictures.

CECIL E. NEWELL: May I ask Dr. McLaughlin what the screw is made of, if it is also vitallium, or what metal?

HARRISON McLAUGHLIN (closing): I thank Dr. Marble for his kind remarks and agree completely with everything he said, with one exception. He made the statement that frequently it was felt necessary or desirable to obtain fixation in intertrochanteric fractures. I would make an even stronger statement.

Our experience over the last fifteen years has been that under any method of treatment the mortality and the severity of the injury, not alone to the bone but to the patient, has been, if anything, greater in the intertrochanteric than in the neck fractures. As a result, we feel utterly convinced that intertrochanteric fractures require fixation just as much as do neck fractures, not for the fracture, because it will heal regardless of

the method of treatment, but in order to mobilize the patient and minimize the incidence of general complications.

The material the instrument has been made of to date has been vitallium, primarily because of the ease with which vitallium can be cast into shape. The question of the expense of making it out of stainless steel has not been explored as yet. It may be possible to machine an instrument that will serve the purpose.

# THE TREATMENT OF TROCHANTERIC FRACTURES

CECIL E. NEWELL, M.D.

CHATTANOOGA, TENNESSEE

THE greatest advance in the treatment of trochanteric fractures followed the popularization of internal fixation for fractures of the neck of the femur. In spite of the fact that internal fixation was attempted for transcervical fractures in the last century<sup>24</sup> and was used successfully in America the year I was born,<sup>11</sup> the method was not widely adopted until Smith-Petersen advocated in 1931 the use of his three-flanged nail and Johansson and Henderson a year or so later made "blind" nailing possible by cannulating it. To these men, as well as to Clayton Johnson and the others<sup>6,20,32</sup> who made the lateral x-ray of the neck of the femur possible and to Venable and Stuck, who introduced the isoelectric alloy vitallium to bone surgery, we owe an everlasting debt of gratitude. Following these advances, there rapidly followed a new area in the treatment of fractures of the neck of the femur and everyone began to "nail" these fractures. Results were so dramatic and hospitalization so shortened that it is little wonder that the wave of enthusiasm soon spread to include trochanteric fractures.

Internal fixation, however, for the treatment of trochanteric fractures received opposition from two sources. First, there were still a number of conservative die-hards,<sup>1,9</sup> as there always are to oppose anything new, who said that all trochanteric fractures would unite anyhow, so why operate? The answer to this lies in the summation of the following eleven facts:

1. The incidence of trochanteric fractures is high. These fractures occur more often than those of the neck of the femur.<sup>18</sup>
2. Trochanteric fractures occur in older individuals.<sup>2,18,30</sup>
3. The trauma which causes a trochanteric fracture is more severe than that which causes a cervical fracture of the femur.<sup>30</sup>
4. The trauma consists of a direct blow upon the trochanter and results in more hemorrhage and soft tissue damage.<sup>18,30</sup>
5. There is apt to be comminution of the fragments.<sup>18,30</sup>
6. Because of 1, 2, 3, 4 and 5 the mortality of trochanteric fractures is greater than for fractures of the neck of the femur.<sup>18,30</sup>

in spite of the fact that for years trochanteric fractures has enjoyed the better prognosis. This, naturally, was based upon the comparison with the poor results formerly obtained in fractures of the femoral neck.

7. If internal fixation is applied, patients with trochanteric fractures are immediately freed of most, or all, of their pain.<sup>30,35,38</sup>

8. With adequate internal fixation, these patients may sit up in bed and are soon ambulatory without the aid of casts, braces, splints or any external fixative appliances.

9. Hospitalization in these fractures is reduced to a minimum, thus reducing expense. In these critical times of hospital shortage, nailing trochanteric fractures releases a bed within a week or two, whereas, the hospital space would be tied up from two to six months if the patient were treated by traction.

10. Stiffness of joints, atrophy of limbs and bed sores which so frequently followed the long periods of immobilization in the older methods of treatment are absent in patients who have been nailed.

11. The mortality in the aged following internal fixation is much less than when these debilitated, old people were kept in bed for months treating them with old style methods.

The problem in young or middle-aged adults is different, for non-union is never experienced and death seldom results from their being bed-ridden. If hospital space and expense are not of importance and the surgeon or patient chooses it, these younger patients may be treated by closed reduction and traction or often very satisfactorily simply by traction.

The second source of opposition to internal fixation in trochanteric fractures is voiced by those who have experienced difficulties and complications by various methods which, though highly satisfactory for fractures of the neck of the femur, are not satisfactory for trochanteric fractures. Most of these difficulties can be overcome by a little thought and ingenuity. For instance, we have found, as have others,<sup>4,18,35</sup> that the Johansson nail is so large that it frequently splits the thin trochanteric spicule attached to the shaft of the femur when the nail is inserted. This can easily be prevented by boring with a special drill (Fig. 1) a hole in the lateral cortex large enough to allow the nail to be inserted. I now do this routinely. The drill used is a cannulated one which can be slipped over the pin selected to guide the nail.

Because of the tendency of Kirschner wires to bend, they have been found to be too flexible for our use. At our Clinic, therefore,



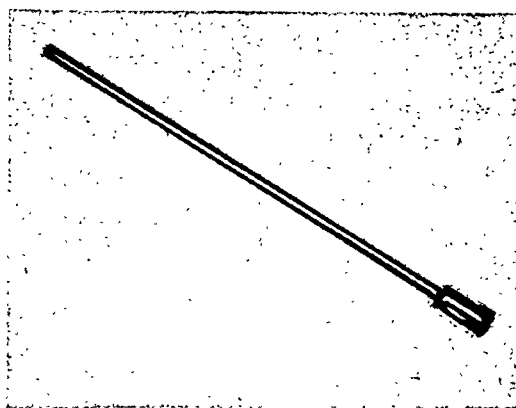


FIG. 1. Photograph of drill for making hole in lateral cortex.



FIG. 2. Anteroposterior roentgenogram of comminuted trochanteric fracture following reduction.



FIG. 3. Varus deformity of same femur shown in Figure 2 which occurred after nailing.

we always use two or three small Steinman pins  $\frac{3}{32}$  inches in diameter to maintain our reduction and the nail is threaded over the pin which is in the best position.

Carothers and others<sup>12</sup> have stressed the importance of obtaining a good normal angle or even a slight valgus position of the head and neck when the fracture is reduced. The Smith-Petersen or Johansson nail cannot hold trochanteric fractures in good position unless the fracture line is near the base of the neck. Too often, following an excellent reduction (Fig. 2) and the insertion of a Johansson nail, because of insufficient grip, a varus deformity develops (Fig. 3) or a sliding of the fracture takes place. (Fig. 6.) To prevent this, we employ the Johansson nail with the Jewett shank and five screws.

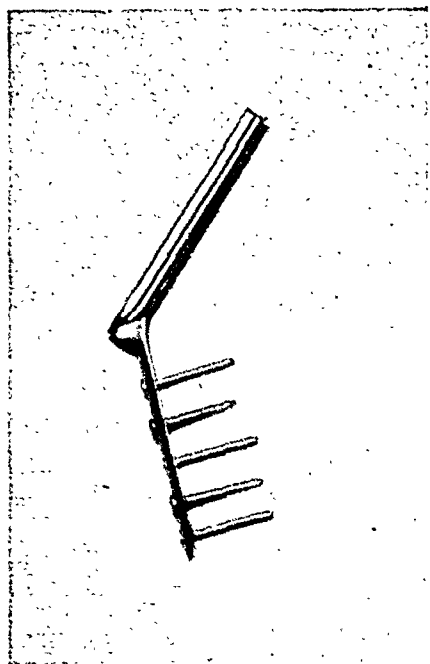


FIG. 4. Photograph of Vitallium Johansson nail with Jewett shank and five Vitallium screws.

(Fig. 4.) This nail will maintain reduction and is strong enough to hold a person up without breaking, though weight bearing is not advocated. The shank is made of Vitallium and is not screwed on to a regular nail as formerly but is cast as a single piece with the nail. It comes in different lengths and at different angles to the shank, (Fig. 5) the more obtuse the angle, the better. A  $3\frac{3}{4}$  inch nail and angle of  $135^\circ$  is a good one for the average trochanteric fracture. But, a surgeon should have an assortment of three or four on hand for femurs of different size and shape. Naturally, the more obtuse the angle, the longer the nail required. There are many other types of good nails available<sup>25, 36, 39, 40</sup> but we prefer the nail described above because it is made in one piece of Vitallium and because we are accustomed to the technic of blind nailing with a cannulated Smith-Petersen nail.

We have noted, as have Siris and Ryan, that occasionally driving in the three-flanged nail after a satisfactory reduction causes a dispersion of the fragments. This is usually caused by the nail being driven into the fracture line and is eliminated when a nail with shank is used because the surgeon can visualize the fracture site at the open operation which is required for this type of fixation.

Key and others<sup>16, 41, 42, 43</sup> have noted the deleterious effect on fractures caused by the absorption of bone due to the use of steel fixative

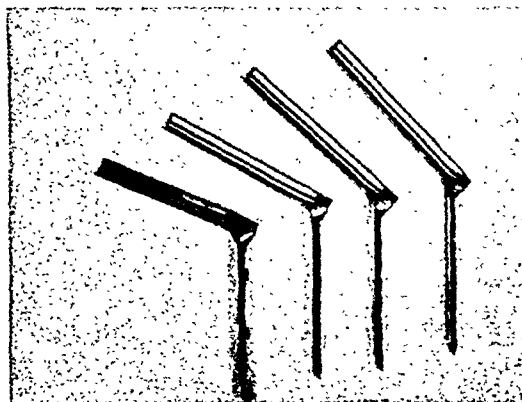


FIG. 5. Photograph showing different length nails and different angles of the shank.

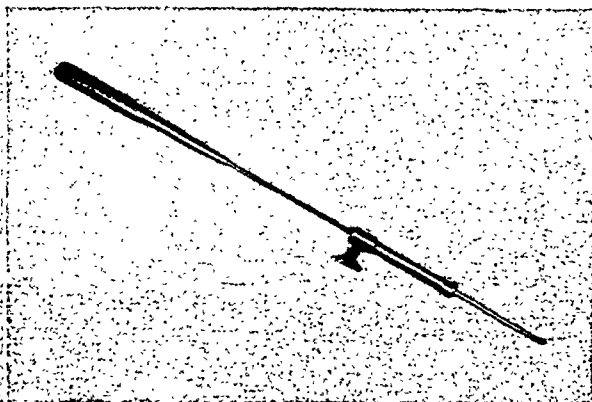


FIG. 6. Photograph of depth gauge to determine exact length of screw needed for plates.

appliances of different compositions. For this reason, at the Newell Clinic, we never use anything in these fractures but Vitallium. With its use, we have noticed very little bone absorption and never any loosening of shank, nail or screws.

We formerly used the Moore pins for trochanteric fractures (Figs. 14 and 15) but have discarded this method as have others,<sup>34</sup> because we can apply the Johansson nail with Jewett shank faster and also believe it to be stronger. Then, too, this nail with shank is applicable to more types of trochanteric fractures.

*When to Operate.* Because fractures of the trochanters occur so consistently in the aged who are already fragile and debilitated, the trauma is frequently quite a shock to the patient. In fact, so major is the accident that it sometimes terminates fatally within the first day or so in spite of sedation, traction, blood transfusions and other supportive measures. The gravest complication of hip nailing is to operate on one of these individuals who is going to die anyway but, because of the added shock of nailing, dies a little faster. If you are sure your patient is not one of these, then the sooner you operate, the better. If you are not sure and the patient appears to be a very poor operative risk or in a grave condition, it is wise to wait a day or two to see which way he progresses. If the patient's general condition fails to improve or declines, it is wisest to wait even longer until improvement does take place or death intervenes.

*Operative Technic.* After cautious preoperative sedation, the patient is placed on the x-ray table. A spinal anesthesia is routinely employed, using a procaine-pontocaine mixture,<sup>31</sup> which has been found to be highly satisfactory for this operation.



FIG. 7. X-ray of right hip showing comminuted intertrochanteric fracture.

The fracture is then reduced by traction and slight internal rotation of the affected extremity. A roentgenograph is then taken and the patient is prepared and draped while the film is being developed. The femur is approached through a lateral incision exposing the distal portion of the greater trochanter and about four or five inches of the femur.

After the reduction is confirmed by the x-ray, vision and palpation, a site approximately 1 inch below the greater trochanter is selected and a Steinman pin of  $\frac{3}{32}$  inch calibre is stuck into the cortex and its position and the angle is checked by the fluoroscope. The pin is then drilled well into the head, checking its progress fluoroscopically. Another pin for stabilization of the fracture is drilled parallel to and about 1 cm. away from the previous one. Anteroposterio and lateral roentgenographs are now taken, using the "frog position" for the lateral view. The pin that is in the best position in both views is selected to guide the nail. If neither pin is satisfactory, a third one is drilled, correcting its direction by comparing the position of the first and second pins. The cannulated



FIG. 8. Roentgenogram of hip after reduction and insertion of Johansson nail with Jewett shank and screws.



FIG. 9. Lateral roentgenogram of same case shown in Figure 8.

bit shown above (Fig. 1) is now threaded over the pin selected and a hole is bored in the cortex, after which the bit is withdrawn.

A Johansson nail with Jewett shank of proper angle is now selected and threaded over the pin. The driver is screwed into the nail, after which the nail is pushed through the drill hole and driven through the neck into the head until its shank rests upon the femur. The driver is unscrewed and removed, and all Steinman pins are withdrawn.

Screw holes are now bored with a  $\frac{7}{16}$  inch drill through both cortices of the shaft of the femur. The exact depth of the holes, which is equal to the thickness of the shank plus the diameter of the femur, is accurately determined for each hole by the use of a gadget which is sometimes referred to as the Jackson-Gallagher depth gauge. (Fig. 6.) By its use, dangerously long screws need never be used and those of exact length can be selected.

After the screws are securely placed, two or three Gm of sulfanilamide are left in the incision, which is closed in layers without drainage. Anteroposterior and lateral roentgenographs are taken as



FIG. 10. X-ray five months after nailing showing callus.



FIG. 11. Lateral roentgenogram showing union.

a matter of record, and the patient is returned to bed without external support of any kind.

#### CASE REPORT

W. N. W., eighty-three year-old white male, slipped on the ice on December 19, 1945. He fell, striking his right hip on the frozen ground. He was so helpless he could not get up. He was found and carried to his home. His family physician was called and it took three days to convince the patient and his family that hospitalization was necessary.

Upon admission, the old man was irrational, his temperature was  $100^{\circ}\text{F}$  and his pulse 120. His weight was estimated at 130 pounds. The right lower extremity was helpless. It was slightly shorter than its fellow and lay in external rotation. X-ray (Fig. 7) showed a comminuted intertrochanteric fracture.

After forty-eight hours of light skin traction and the administration of penicillin, morphine, whiskey and food, the old man's general condition

was slightly improved. So under spinal anesthesia, using 60 mgm. of procaine and 6 mgm. of pontocaine, the fracture was reduced and internal fixation was accomplished using a  $3\frac{3}{4}$  inch vitallium Johansson nail with 4 inch Jewett shank at an angle of 140 degrees. The shank was anchored to the shaft of the femur by five  $1\frac{1}{4}$  inch vitallium screws. Three Gm. of sulfanilamide were dusted in the incision, which was closed in layers without drainage. A.P. (Fig. 8) and lateral roentgenographs (Fig. 9) were taken.

On the following day, the old man was sitting up in bed free of pain. He was up in a wheel chair on the sixth postoperative day. His sutures were removed on the tenth postoperative day and he was then discharged from the hospital with instructions to bear no weight on the leg and to return in three months for x-ray.

He was not seen again until he walked into my office five months later. A.P. (Fig. 10) and lateral x-rays (Fig. 11) at this visit showed satisfactory union was taking place. He was asked when he had started to walk. He replied and his family verified it, that he walked without aid the first week after he returned home.

#### SUMMARY

Internal fixation is the method of choice in the treatment of trochanteric fractures of the femur in the aged.

A vitallium Johansson nail with Jewett shank anchored with vitallium screws is the author's choice of fixative appliance. It is strong, relatively easy to apply and is suitable for all types of trochanteric fractures, especially for badly comminuted ones.

A Smith-Petersen type nail without a shank is not satisfactory for the fixation of trochanteric fractures of the femur, particularly comminuted ones.

Several adjuncts which have been found useful in preventing difficulties and complications in internal fixation of trochanteric fractures are discussed and illustrated.

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### DISCUSSION

RALPH G. CAROTHERS (Ohio): Dr. Newell has covered this subject so well that there is very little left to discuss. However, I should like to point out a little of my own experience.

At the Boston meeting of this Association we reported 120 odd cases of fracture of the neck and femur which we had nailed. These cases were all of the transcervical type. We had at that time also operated upon some sixty patients with the intertrochanteric type which we did not report. This year, since January 1st, we have operated upon twice as many intertrochanteric fractures as transcervical.

In other words, several years ago we were not operating upon the intertrochanteric fractures very often, and now we are operating upon them much more often. We have continued to use a nail similar to the Austin Moore type. It is a little larger and a little stronger nail than the ones which Austin Moore himself uses, or the ones which Dr. Newell showed in his photographs.

We have found that in the vast majority of cases we can do the operation and get good adjustment of fragments and hold them well with these nails and the advantage of them is tremendous. The incision is so short that it takes not more than two sutures to close it. The time of the operation is not over five minutes, with the additional time that of course is used in waiting for x-rays to come through. The actual operation procedure takes not over five minutes and the trauma to the soft tissues is almost nil.

We think the trauma to the soft tissues in these persons is an important factor. We have gone around to other hospitals and have seen plenty of fat necrosis, and we have had some ourselves and it isn't very nice. Therefore, we think whatever operation can be done which gives the least amount of trauma is the best. It is true that there are some cases in which the fragmentation of the bone is so great that this type of procedure must be used. We have some of these nails at home which we have had for several years and we have not had to use one of them yet.

KELLOGG SPEED (Chicago): I do not wish to make myself objectionable, gentlemen, but I believe there is too much tendency to operative treatment of this type of fracture. Since reporting a series of 125 cases over thirty years ago I very seldom, if ever, operate upon these fractures.

Let us go back to what Dr. Quigley has just shown us in relation to the phalangeal and metacarpal fractures. If we treat the patient as a whole and make traction on the limb, either by skeletal or muscle traction, you may obtain perfect reductions. That traction does not have to be on very long. They may move the knee and the hip slightly, even as his patients moved their fingers. You should get a proper union.

I think we are throwing too much stress on the imbedded metallic fixation pulling against the powerful muscles in the thigh and not relying enough upon simpler measures in older patients which the essayist kindly acknowledged as being those who obtain this fracture.

In the older people we are all a little hesitant about performing an operative procedure and I think that hesitation overweighs, by and large, the advantages obtained by the freedom of leg motion which the fixation might give. I would like to hear further discussion from those who may object to operative procedures.

HOMER STRYKER (Kalamazoo, Mich.): I just want to bring out a point or two that I have learned in nailing a considerable number of these. One is in regard to the external rotation or the internal rotation in nailing these fractures.

Of course, with a fracture through the neck all the external rotators are fastened to the distal fragment, to the shaft of the femur and to the trochanteric region posteriorly and they tend to rotate the distal fragment exteriorally. In these fractures you want to get as much internal rotation as possible. We have a little gadget with our Cassette holder that lies on an ordinary operating table. Both feet are dropped over the foot, as we drop the end of the table and with two little arms on the side we hold both legs in internal rotation with the knees flexed at about 45 degrees. One side fixes the pelvis, the good side, while the other side holds the leg in internal rotation. I have never seen one that had too much internal rotation.

With intertrochanteric fractures the external rotators are attached to the upper fragments. They may be attached to loose fragments in the trochanter but the fracture line is usually below most of these; so if you hold the leg in internal rotation, as you do in a transcervical fracture, you find you have a distortion between the shaft and the neck.

I find if you keep the leg in slightly external rotation and just a little flexion, it falls into position a good deal better. There is always a tendency for an anterior angulation. If you will notice on the slide, there was a little tendency to anterior angulation. By flexing the table at the center so the hips are slightly flexed and by dropping the foot, the legs drop over the end of the table; then turn the table up so the patient's head is down.

The legs are held and traction is maintained all during the operation. Unfasten the foot, flex and externally rotate the thigh to take the lateral x-rays.

Those are just a couple of points I have found which have helped me a great deal. The type of nail selected has to fit the individual case depending upon the height, the amount of comminution, the condition of the patient and a lot of other factors.

CECIL E. NEWELL (closing): I enjoyed the discussion very much and have little to add. I am sorry if my point about internal fixation in trochanteric fractures was misinterpreted. I believe that these fractures should be nailed not to get union, because patients with trochanteric fractures will get union anyway but simply to get these old people out of bed and make them ambulatory earlier, thereby reducing mortality.

No matter how old the patient is, I do not hesitate to operate on him if he is in good condition. It is unwise to attempt any operative interference on a patient who is in very poor condition, no matter what the age. If the patient is in good condition, or if his condition has been poor and is improving, I find that they give no trouble at all when their fracture is reduced and internal fixation is applied under a small, low spinal anesthesia.

# INTERPHALANGEAL JOINTS\*

## A METHOD OF DIGITAL SKELETAL TRACTION WHICH PERMITS ACTIVE MOTION

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EXPERIENCE during the recent war with both simple and compound fractures of the metacarpals and phalanges has re-emphasized the importance of vigorous, active motion throughout the period of treatment. Even in the presence of grave bony deformity, fair function will occasionally result if immobilization by plaster of paris or other splints is reduced to the minimum both in extent and time. Of course, the best results are achieved if the bony framework of the hand is restored as closely as possible to normal. Nowhere else in the body are motion and function more closely related to anatomical structure. If, following an injury, motion in the hand is discontinued for even a short time, a very large area of complex, gliding surfaces tends to become adherent. The rapid development of stiffness in the injured hand as compared to the larger joints of the body is due to its relatively greater area of joint surface, capsule, ligament and tendon. As a general rule, the smaller the joint, the more predisposed is the part to stiffness.

In the treatment of fractures of the phalanges and metacarpals, manipulative reduction followed by traction is very often the method of choice. Unfortunately, the usual methods of traction do not permit active motion.

There are, recommended in the literature or in common use, five sites for traction in the finger, each of which presents certain disadvantages.

1. *Fingernail*.<sup>1</sup> (Fig. 1A.) If sufficient force is applied to reduce a fracture of a metacarpal or phalanx, considerable discomfort is produced in the nail bed.

2. *Pulp of the Distal Phalanx*.<sup>2</sup> (Fig. 1B.) Effective traction at this site is often painful and may result in ischemia and even gangrene of the tissues distal to the pin or wire.

\* From the Laboratory for Surgical Research. Harvard Medical School.

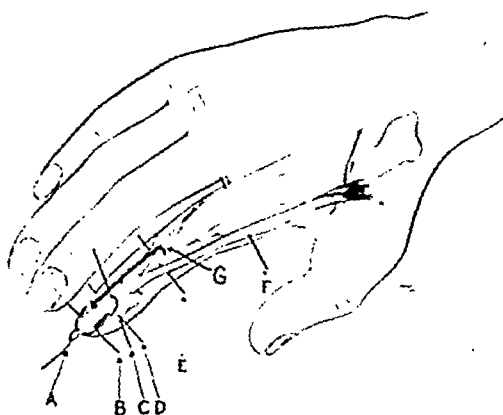


FIG. 1. Commonly employed sites for digital traction (A, B, C, D, E, F) and the traction hook in the middle phalanx which permits active motion of the interphalangeal joints.

3. *Distal Phalanx.*<sup>3</sup> A wire passed vertically or anteroposteriorly (Fig. 1C) is apt to produce a tender scar on the sensitive pad of the finger tip. This objection is obviated by a wire in the transverse plane, (Fig. 1D) but traction originating in the terminal phalanx immobilizes the metacarpal-phalangeal and all the phalangeal joints, is largely spent in the chain of phalanges, and predisposes to stiffness.

4. *Middle Phalanx.*<sup>4</sup> (Fig. 1E.) Injury to the lateral slips of the extensor tendon complex or the digital neurovascular bundles is difficult to avoid. The distance between these structures is not great, particularly in flexion.

5. *Proximal Phalanx.*<sup>5,6</sup> (Fig. 1F.) It is almost impossible to insert a wire transversely through the proximal phalanx without perforating the lubrical-interosseus components of the extensor tendon complex. The same objection can be raised against the use of a towel clip in the neck of the metacarpal.

There is only one area in the finger where skin directly overlies fascia and bone. This is a triangular space on the dorsal surface of the middle phalanx, bounded subcutaneously by the lateral terminal slips of the extensor tendon complex, and proximally by the insertion of the middle slip. Between the lateral extensor tendon slips is a filmy layer of fascia which serves to keep them from diverging from each other. This triangular space would appear to be the site of choice for skeletal traction, since it contains no structures which are necessary for motion. Anomalies of the insertions of the extensor



FIG. 2. Roentgenogram of four hooks in place for compound fractures of the second, third, fourth and fifth metacarpals. The surface of the hand has been coated with barium paste.

digitorum communis, lumbricales and interossei have been described, but are not common. None have been encountered in the dissection of twenty fingers, in the literature,<sup>7,8</sup> or in clinical application which would contraindicate the use of the dorsum of the middle phalanx for skeletal traction.

Traction is maintained by a hook fashioned from a Kirschner wire to the approximate size of a No. 4 fish hook. (Fig. 1G.) A tiny stab incision is made over the exact center of the dorsal aspect of the middle phalanx and with a No. 6 dental burr a hole is drilled into the marrow cavity at an angle of 45 degrees distally. The end of the hook is slipped into the hole, so that its end engages the cortex firmly and its curve rises perpendicularly to the surface of the skin. A small piece of gauze is held in place about the point of insertion with adhesive tape, which also serves to steady the curve of the hook. No complications have occurred in more than seventy fingers placed in traction by this method and observed for from four to six weeks after removal of the hooks. Active motion is insisted upon throughout the period of traction. The range of motion is not great, but is



FIG. 3. Case 11. Compound comminuted fractures of third and fourth proximal phalanges before reduction and hook traction.

sufficient to prevent "freezing" of the interphalangeal joints and flexor and extensor tendons. Traction is rarely continued for more than three weeks.

The method is best suited for fractures of the proximal interphalangeal joints, proximal phalanges and unsupported metacarpals. Fractures of single metacarpals, with an intact metacarpal on each side and not greatly displaced, usually can be managed by simple plaster or other splints. Similarly, transverse fractures of metacarpals, even when multiple, can often be reduced by manipulation and held in position by splints.

Traction alone ordinarily cannot be depended upon to reduce displaced fractures of the metacarpals and phalanges. Manipulation is almost always necessary. The position of the hand while in traction is of great importance. The first fifty fingers treated by this method of traction were placed in approximately 160 degrees of extension. It was found, when the hooks were removed, that while quite a satisfactory degree of motion was present almost at once in the interphalangeal joints, the metacarpal-phalangeal joints remained stiff and recovered their function only very slowly. During



FIG. 4. Case 11. Hook traction in place after reduction.

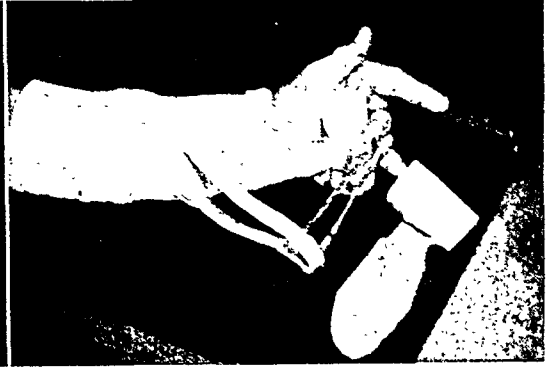


FIG. 5. Case 11. Traction hooks in place.

this period, the hand, or the digits involved, were practically useless, since grasp and opposition against the thumb were not possible. The last twenty cases have been placed in traction in flexion as recommended by Bunnell.<sup>10</sup> In these, after removal of the hooks, motion at the interphalangeal joints was the same, and the metacarpal-phalangeal joints still required prolonged rehabilitation; but, during the convalescent period, the hand was very useful. Extension at the metacarpal-phalangeal joint appeared to be quite as difficult to regain as flexion, but far less important from the point of view of functional usefulness.

The following are reports of three cases, each illustrating certain applications of the method:

#### CASE REPORTS

**CASE 1.** *Gunshot wound of left hand; compound comminuted fractures of second, third, fourth and fifth metacarpals:* A. B. a twenty-four-year old infantryman sustained a gunshot wound of the left hand while in combat. The missile entered on the lateral aspect of the second metacarpal, traversed the palm shattering all four metacarpals and destroying the bulk of the abductor digiti quinti muscle at the wound of exit. None of the flexor or extensor tendons were divided. At an evacuation hospital, a few hours after the wounding, the wounds were débrided, lightly packed with vaseline gauze, and the whole hand and forearm were immobilized in a plaster of paris cast. Forty-eight hours later at a general hospital in the Communication Zone, under pentothal anesthesia, the cast was removed, the fractures reduced as well as possible by manipulation, and hooks were inserted into all four middle phalanges. A "banjo" plaster forearm cylinder was applied with the wrist in extension. Strong elastic band traction was arranged from the hooks to the loop of the "banjo" with the fingers in about 160 degrees of extension at the metacarpal-phalangeal joints. (Fig. 2.) Fifteen to twenty degrees of active motion was possible in the interphalangeal joints the





FIG. 6. Case III. Simple displaced fracture of distal end of fifth proximal phalanx.

next day. A few days later secondary suture of the wounds of entrance and exit were carried out. Both healed without sepsis. Traction was removed after three weeks and a simple volar plaster splint fitted with the wrist in extension. The patient was kept under observation for six weeks after removal of the traction hooks. At the time of the transfer to the Zone of the Interior, he had approximately 30 degrees of motion in the metacarpal-phalangeal joints and 45 degrees of motion in the interphalangeal joints, and was able to oppose the thumb to the tips of the fingers.

**CASE II.** *Compound fracture of the third and fourth proximal phalanges from crushing injury; hook traction with metacarpal-phalangeal joints in flexion:* J. T. L., a twenty-eight-year old soldier, while repairing some heavy gravity rollers, accidentally caught his left hand between them, sustaining compound fractures of the third and fourth proximal phalanges. A few hours after the accident, the wounds were débrided and closed. Manipulative reduction of the fractures was carried out and the hand and forearm were immobilized in a plaster cast. X-rays showed poor position of the fragments. (Fig. 3.) Four days later, at another hospital, the cast was removed and hook traction, with the fingers and metacarpal-phalangeal joints in flexion, was instituted. Check x-rays showed satisfactory position and alignment of the fragments. (Fig. 4.) There was a good range of motion in the distal phalanges of both fingers in traction. (Fig. 5.) Two weeks later, the hooks were removed. Six weeks after the injury motion of the phalanges was normal. Extension at the metacarpal-phalangeal joints lacked 30 degrees of normal, but the functional usefulness of the hand was good.

**CASE III.** *Simple fracture, two thirds of distal articular surface of left fifth proximal phalanx; hook traction in flexion for twelve days:* J. D., a sixteen-year old schoolboy, twisted his left fifth finger outward and backward playing basketball. An x-ray film showed a fracture of the distal end of the



FIG. 7. Case III. Traction hook in place, after manipulative reduction.

proximal phalanx with approximately two thirds of the flexor aspect of the joint surface displaced. (Fig. 6.) Hook traction was instituted on the day after the injury with the metacarpal-phalangeal and proximal interphalangeal joints flexed to almost 90 degrees each. Check x-rays showed good reduction. (Fig. 7.) A wide range of motion of the interphalangeal joints was possible with the traction hook in place. Traction was removed twelve days later, and the finger taped to the fourth finger. The tape was discarded after a week. Five weeks after injury, motion of the finger and metacarpal-phalangeal joint was normal save for a lack of 10 degrees of complete extension at the proximal interphalangeal joint.

#### SUMMARY

1. A new method of digital skeletal traction is described, which is atraumatic and permits motion at the interphalangeal joints.
2. Application of this method has been made with fingers in extension and in flexion. It has been observed that while the rate of return of function is the same for either position, flexion is preferable since the usefulness of the hand is much greater during the period of rehabilitation.
3. The indications for digital traction are reviewed.
4. Three pertinent cases are presented.

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#### DISCUSSION

HENRY C. MARBLE (Boston): I think it is desirable to start a meeting in Texas with a considerable dose of Boston accent, and that is why Dr. Quigley started and why I am second. You will not have any more Boston accents for a long while in the heart of Texas.

This is an interesting paper, interesting because just after the last war, or thereabouts, we first began using the banjo splint. That was a tremendous advantage over the old straight splint in which all hands were retained.

Now Dr. Quigley has studied the anatomy of the finger. In teaching I often call the attention of my students to the tremendous interest there is in the anatomy of the knee joint. You can arouse a great deal of interest any time if you start to discuss the anatomy of the knee joint. When you begin, as Dr. Quigley has done, to discuss the anatomy of the proximal interphalangeal joint of the finger, the medical students usually lose interest and appear as though it was not important.

If you wish to study that, you will find that the anatomy of the proximal interphalangeal joint of the finger is not only as complex but more complex than the knee joint. True, you have no meniscus which has kept great groups of men happy for a long time, but you have tendons which are on the flexor surface acting as extensors, and in fact the whole extension of the proximal distal phalangeal joints come from muscles which, instead of being on the back or proper side of the hand, are on the front and in the palm. This, with a very complex slipping mechanism, which slips, in fact, over the entire back of the hand, makes any injury to these little bones much more serious than in a relative place in the leg.

Therefore, detailed knowledge of the anatomy of the finger is necessary. Dr. Quigley has taken advantage of that detailed knowledge and has found a place in the middle phalanx where he can insert a hook and can get traction. That is a distinct advantage, a distinct help, and in addition to that, he can get traction in the proper line. Sometimes in lesser flexion, sometimes in greater flexion, but always traction. It is an excellent method and I commend it.

There is one thing in his paper which he said but did not emphasize in his review, which I will emphasize, and that is this method of traction in my opinion should not continue for more than two and a half weeks. If the results can be obtained in a shorter period, I would be happy to remove the traction in two weeks.

In a study of the fractures of the hand which I made some years ago, we found that the longest and most disabling group of injuries were not of the metacarpals but were of the proximal phalanges.

The third thing which he did not bring out, and which I want to call to your attention, is that the x-ray evidence which you have following such an injury as he has described here is often misleading. Long after the patient has clinical union the x-ray shows the line of fracture. I believe that studies have shown that the patient, after clinical union is obtained, has lack of x-ray union as many months as it took weeks for him to obtain clinical union; that is, if the patient has solid bony union clinically in six weeks, it will take six months to show it in the x-ray.

Therefore, using the x-ray as a guide, I think it is very dangerous, and the traction should be removed as early as you safely can, and I am sure our results will be correspondingly better.

PRESIDENT PENBERTHY: Thank you, Dr. Marble. Is there any further discussion of this paper?

GEORGE W. BANCROFT (New York): I did not see how the hook went in without penetrating the dorsal tendon. Does it penetrate the dorsal tendon in the distal phalanges?

THOMAS B. QUIGLEY (closing): It does not, Dr. Bancroft. The tendon normally inserts at the proximal end of the middle phalanx. Occasionally, it will extend up further, in which case the hook does split it, but it does not interfere with activity.

GEORGE W. BANCROFT: You put it in the proximal, too? How do you avoid the tendon?

THOMAS B. QUIGLEY: We never put in it the proximal, always in the middle phalanx.

# CAUSES OF DEATH IN BATTLE CASUALTIES REACHING HOSPITALS

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**H**OSPITAL battle casualty mortality rate tends to vary inversely with battlefield mortality rate. Approximately ten times as many men die on the battlefield or on the way to a hospital, as die after reaching a hospital. The more accessible the hospital the higher will its mortality rate be. Table 1 gives statistics on the 91,631 American soldiers who were killed, wounded or injured in action in Italy between January 1, 1944 and May 2, 1945. It is noted that while 16,648 died on the battlefield, only 1,631 died in a hospital. These 1,631 cases comprise only 8.9 per cent of all the deaths. At Anzio, where all hospitals were quite accessible, 16 per cent of all battle casualty deaths occurred in hospitals. The hospital mortality rate at Anzio was 5.7 per cent.<sup>1</sup> Later tables show that the hospital mortality rate for the whole period was only 2.59 per cent.

Figures on 5th Army casualties are given dating from January 1, 1944, rather than from September 10, 1943, the date of the invasion of Italy, because beginning January 1, 1944, the surgeon requested submission of a complete clinical report and autopsy record on every battle casualty who died in Fifth Army Hospitals. Reports on 1,411 of the 1,631 deaths were received in time to be used in a study of hospital battle casualty deaths. Machine record methods were used in making the study. Study of the cases and a primary recording of these data consumed the entire time of one of us (JWC) for a period of a little over three months. The other of us studied each case and checked the recorded data. Each item was carefully weighed, matters calling for opinion were discussed and all questionable data were recorded as questionable. Transmission of the recorded data to machine records cards and assembling the data in a three volume preliminary report<sup>2</sup> consumed the entire time of both of us and a large clerical staff for two more months. The 1,411 cases studied

may be assumed to be truly representative of the total of 1,631 who died in Fifth Army Hospitals. In addition to the 1,411 cases who died in hospitals, the records of thirty-nine who were dead on arrival at hospitals were included in the study. Table II shows the number of cases studied in each of four periods, and the number in which

TABLE I  
FIFTH ARMY AMERICAN CASUALTIES\*  
1 JANUARY 1944 TO 2 MAY 1945

	Number	%
Killed in action or died before reaching a hospital.....	16648	18.17
Wounded or injured in action, returned to duty without hospitalization .....	11959	13.05
Wounded or injured in action, admitted to a hospital and lived....	61393	67.00
Wounded or injured in action, admitted to a hospital and died....	1631	1.78
Total.....	91631	100.00

\* Does not include missing in action. Data derived from Adjutant General's figures on killed in action, died of wounds, and wounded in action; and from MTOUSA M.D. Form 86 F.

TABLE II  
POST MORTEM STUDIES BY PERIODS  
AMERICAN BATTLE CASUALTY DEATHS REPORTED BY FIFTH ARMY HOSPITALS

	Jan-Mar 1944	Apr-Jul 1944	Aug-Dec 1944	Jan-May 1945	Total
Number of deaths studied.....	529	482	284	155	1450
Number with gross autopsy reports.....	171	254	180	128	733
Percentage with gross autopsy reports.....	32.3	52.7	63.4	82.6	50.6
Number with microscopic sections reported.....	37	119	99	94	349
Percentage with microscopic sections reported.....	7	24.7	34.9	60.6	24
Percentage of gross autopsies with microscopic sections reported...	21.6	46.9	55	73.4	47.6

autopsy reports were available. It will be noted that gross autopsy reports were available on a little better than 50 per cent of all the deaths studied. It may also be noted that in the last period, or during 1945, autopsies were performed on 82.6 per cent of those who died in hospitals. Most of these autopsies had to be performed by the operating surgeons. Those of you who are familiar with the work a surgeon must do in a forward hospital during an offensive will

realize fully what a tribute this record is to the scientific zeal of the surgeons working in Fifth Army Hospitals.

TABLE III

FIFTH ARMY HOSPITAL AMERICAN BATTLE CASUALTY DEATHS AS RELATED TO HOSPITAL ADMISSION, ANESTHESIA AND SURGERY\*

	Cases	Percentage
Dying on admission (lived less than 1 hour).....	74	5.24
Died before anesthesia (excludes those dying on admission)....	337	23.88
Died during anesthetic induction.....	16	1.13
Died during primary surgery.....	75	5.32
Died after primary surgery.....	909	64.42
Total.....	1411	100.00%
Dead on arrival.....	39	

\* Based on a study of 1411 cases out of a total of 1631 occurring January 1, 1944 to May 2, 1945.

TABLE IV

PERCENTAGE OF DEATHS IN HOSPITAL BATTLE CASUALTY ADMISSIONS\*

	Jan- Mar. 1944	Apr- July 1944	Aug- Dec. 1944	Jan- May 1945	Total
Percentage dying before anesthesia.....	1.39	0.68	0.44	0.44	0.752
Percentage dying during anesthesia or surgery.....	0.211	0.141	0.171	0.165	0.167
Percentage dying after anesthesia or surgery.....	2.34	1.52	1.44	1.435	1.671
Total percentage dying in hospital.....	3.94	2.34	2.05	2.04	2.59

\* Based on study of 1411 American battle casualty deaths reported by Fifth Army Hospitals January 1, 1944 to May 2, 1945.

Table III shows the deaths as related to hospital admissions, anesthesia and surgery. With experience and improvement in the preparation of battle casualties for surgery, the percentage of those dying before anesthesia decreased throughout the period covered in this report. Likewise, there was a very slight increase in the number of those who died during anesthesia or surgery. However, Table IV showing percentages based on the number of hospital battle casualty admissions shows not only a reduction in the percentage of those dying before anesthesia, but likewise a decrease in the percentage of those dying during anesthesia or surgery and in the percentage of those dying after anesthesia. The hospital battle casualty mortality rate is influenced not only by its proximity to the battle-front, but

also by the quality of the care administered the wounded who reach it alive.

TABLE V  
DISTRIBUTION OF DEATHS STUDIED BY PRINCIPAL WOUND GROUPS

	Number of Cases	Percentage of Deaths Studied
Intra-abdominal.....	408	28.1
Intracranial.....	297	20.5
Thoraco-abdominal.....	212	14.6
Intrathoracic.....	138	9.5
Lower extremity, with bone involvement.....	114	7.8
Unclassified, multiple wounds.....	114	7.8
Combined intra-abdominal & intrathoracic.....	59	4.1
Lower extremity, soft tissue only.....	31	2.2
Intraspinal (i.e., intravertebral).....	27	1.9
Cervical.....	25	1.7
Upper extremity, with bone involvement.....	10	0.7
Maxillofacial, with bone involvement.....	3	0.6
Upper extremity, soft tissue only.....	4	0.3
Abdominal wall.....	3	0.2
Total.....	1450	100.0

Table v shows the distribution in principal wound groups of the deaths studied. The number of cases in each group and the percentage it comprises of the total deaths are given. It was found that in only 33.3 per cent of the deaths studied were the wounds limited to one of the wound groups listed in this table. Sixty-six and seven tenth per cent had wounds involving multiple regions of the body. Many of the 33.3 per cent had multiple wounds, but they were limited to one of the regions listed in Table v. This table may be compared with Table vi, which shows the distribution of wounds among all battle casualties admitted to Fifth Army Hospitals during the period of 1st of August, 1944, to May 2, 1945. It also shows the mortality rate for each of the principal wound groups. It may be seen that intra-abdominal wounds comprise only 2.84 per cent of battle casualties admitted to hospitals, but 20 per cent of them die and these comprise 28.1 per cent of all hospital battle casualty deaths. Table vii shows that intra-abdominal, intrathoracic, thoracoabdominal, combined intra-abdominal and intrathoracic and intracranial wounds comprise only 11.08 per cent of hospital battle casualty admissions and yet they account for 76.8 per cent of all hospital battle casualty deaths.



While all battle casualties who died may be said to have died of their wounds, this has been deemed inadequate in this study of 1,450 battle casualty deaths. An immediate or precipitating cause of death has been named in all cases in which it could be determined. Table VIII shows the immediate cause of death in the 1,450 cases studied. In 303 of the 1,450 deaths studied, the immediate cause of death was listed as "Undetermined Unclassified." In this group it was felt that the data was insufficient or the evidence too confusing to permit a definite determination of the cause of death. Table IX shows the distribution of these cases by principal wound groups.

TABLE VI  
DISTRIBUTION BY PRINCIPAL WOUND GROUPS OF AMERICAN BATTLE CASUALTIES ADMITTED TO FIFTH ARMY HOSPITALS\*

	Percentage of All Battle Casu- alty Admissions	Percentage That Died in Each Group
Intra-abdominal.....	2.84	20
Thoraco-abdominal plus combined intra-abdominal and intrathoracic ..	1.66	20.4
Superficial abdominal.....	0.74	00.0
Intra-thoracic.....	4.64	7.8
Superficial thoracic ..	3.73	0.2
Intracranial.....	1.05	26.00
Scalp.....	3.77	00.0
Lower extremity soft tissue and bone	9.35	1.74
Lower extremity soft tissue only.....	32.48	0.25
Upper extremity soft tissue and bone.	6.25	0.28
Upper extremity soft tissue only.....	19.30	0.02
Neck.....	2.07	0.87
Spine.....	0.04	7.10
Maxillofacial soft tissue only.....	4.68	0.29
Maxillofacial bone & soft tissue..	1.22	1.50
Eye and ear.....	2.00	0.00
Other.....	2.30	0.55

\* Data based on reports of 22,246 wounded admitted to Fifth Army Hospitals August 1, 1944 to May 31, 1945.

Shock was named as the immediate cause of death in 523 of the 1,450 cases. We have elected to include the uncorrected state of shock as an immediate or precipitating cause of death along with other more specific or standard diagnoses. The cases which are listed as having shock as the immediate cause of death are those in which there was good evidence of peripheral circulatory failure initiated by the initial trauma and hemorrhage and perpetuated by trauma

TABLE VII

DATA ON INTRA-ABDOMINAL, INTRATHORACIC AND INTRA-CRANIAL WOUNDS IN ARMY HOSPITALS

	Percentage of* Battle Casualty Admissions	Percentage of† Battle Casualty Deaths
Intra-abdominal.....	2.84%	28.1%
Thorace abdominal plus combined intrathoracic and intra-abdominal.....	1.65%	18.7%
Intrathoracic.....	4.64%	9.5%
Intra-cranial.....	1.95%	20.5%
Total.....	11.08%	76.8%

\* Data based on reports of 22,246 wounded during period of 1 August, 1944 to 31 May, 1945.

† Data based on study of the records of 1450 battle casualty deaths reported by Fifth Army Hospitals 1 January, 1944 to 2 May, 1945.

TABLE VIII-A

IMMEDIATE CAUSE OF DEATH IN 1450 BATTLE CASUALTY DEATHS REPORTED BY FIFTH ARMY HOSPITALS

Shock.....	523
Neural (brain) trauma &/or intracranial hemorrhage or clot.....	213
Pigment nephropathy.....	68
Peritonitis.....	65
Clostridial myositis.....	51
Pneumonia.....	49
Fat embolism.....	27
Thrombotic embolism.....	20
Spinal cord trauma.....	16
Tracheo-bronchial obstruction, aspirated vomitus.....	11
Tracheo-bronchial obstruction, blood and mucous.....	11
Cerebral ischemia.....	8

TABLE VIII-B

IMMEDIATE CAUSE OF DEATH IN 1450 BATTLE CASUALTY DEATHS REPORTED IN FIFTH ARMY HOSPITALS

Anesthetic agent.....	7
Empyema thoracis.....	7
Intracranial blast trauma alone.....	5
Cellulitis (extra peritoneal).....	4
Myocardial decompensation.....	4
Coronary occlusion.....	3
Pulmonary blast trauma alone.....	3
Respiratory obstruction above trachea.....	3
Abscess, intra-abdominal.....	2
Air embolism.....	2
Infarction of lung.....	2
Intestinal obstruction.....	2

TABLE VIII-C

IMMEDIATE CAUSE OF DEATH IN 1450 BATTLE CASUALTY DEATHS REPORTED IN FIFTH ARMY HOSPITALS

Intracranial blast and other trauma.....	2
Meningitis, intracranial.....	2
Pulmonary blast and other trauma.....	2
Ventricular arrest.....	2
Abscess, intracranial.....	1
Infarction, brain & lung.....	1
Mediastinal hemorrhage.....	1
Meningitis, spinal.....	1
Pneumonitis.....	1
Respiratory failure, cause undetermined.....	1
Sepsis unclassified, abdominal.....	1

TABLE VIII-D

IMMEDIATE CAUSE OF DEATH IN 1450 BATTLE CASUALTY DEATHS REPORTED IN FIFTH ARMY HOSPITALS

Sepsis unclassified, extremity.....	1
Septicemia.....	1
Thoraco-abdominal trauma, unclassified.....	1
Transfusion reaction.....	1
Other intra-abdominal condition.....	2
Other intracranial condition.....	1
Undetermined thoracic condition.....	12
Undetermined intra-abdominal condition.....	4
Undetermined abdominal wall condition.....	1
Undetermined intracranial condition.....	1
Undetermined unclassified.....	303
Total.....	1450

TABLE IX

LOCATION OF PRINCIPAL WOUND IN THOSE CASES IN WHICH THE DIAGNOSIS WAS UNDETERMINED UNCLASSIFIED IN 1450 AMERICAN BATTLE CASUALTY DEATHS REPORTED BY FIFTH ARMY HOSPITALS

	Number of Cases
Intracranial.....	40
Intravertebral.....	3
Maxillofacial.....	4
Cervical.....	3
Intrathoracic.....	23
Thoraco-abdominal.....	46
Intra-abdominal and intrathoracic.....	11
Intra-abdominal.....	91
Abdominal wall.....	1
Upper extremity, soft tissue only.....	1
Upper extremity, bone and soft tissue.....	5
Lower extremity, soft tissue only.....	4
Lower extremity, bone and soft tissue.....	25
Wounds unclassified multiple.....	46
Total.....	303

and hemorrhage with or without the added shock producing factors of cardiorespiratory embarrassment, gross contamination of peritoneal or pleural cavities, or early sepsis, or any combination of these factors. Over half of the 523 cases so listed died before or during surgery. Table x presents data on the etiological factors in

TABLE X

DATA RELATIVE TO HOSPITAL ADMISSION, ANESTHESIA, SURGERY AND ETIOLOGY IN THE 523 CASES\* IN WHICH THE IMMEDIATE CAUSE OF DEATH WAS SHOCK

	Dead on Arrival	Dying on Admis- sion	Died before Anes- thesia†	Died during Anes- thesia Induc- tion	Died during Primary Surgery	Died Subse- quent to Primary Surgery	Total
Etiology of shock:							
Trauma and hemor- rhage.....	15	35	71	0	10	53	184
Contamination or sepsis plus trauma and hemorrhage..	1	2	10	3	11	93	120
Cardiorespiratory embarrassment plus trauma and hemorrhage plus contamination or sepsis.....	1	1	10	0	12	48	72
Cardiorespiratory embarrassment plus trauma and hemorrhage.....	8	17	44	3	15	60	147
Total.....	25	55	135	6	48	254	523

\* 36.1% of 1450 American battle casualty deaths reported by Fifth Army Hospitals January 1, 1944 to May 2, 1945.

† Excludes dead on arrival and dying on admission.

these cases of shock and also data as to the time the death occurred in relation to admission, anesthesia and surgery. No effort was made to separate the factors of trauma and hemorrhage, as both occur in varying degrees and proportion in every battle casualty. In thirteen cases recurrent or delayed abdominal hemorrhage was a factor. In the 254 cases who are listed as dying of shock after primary surgery only forty-three lived more than twenty-four hours after the operation.

In addition to the 523 cases listed as dying in shock there were 750 other cases in which shock was a contributory or associated con-

dition. There was no evidence of shock in only 177 of the 1450 deaths studied. It is not within the province of this report to discuss in detail the etiology of shock. However, it should be stated that clinical experience and laboratory investigations demonstrated that loss of whole blood was the most important factor in the vast majority of battle casualties in shock. The amount of blood lost was far in excess of previous estimates. In 1945 whole blood was given to 40.6 per cent of the battle casualties admitted to Fifth Army Hospitals at a rate of 2.52 pints per casualty transfused.<sup>3</sup> Many casualties were given as much as six or eight pints of blood and a few even more in the first twenty-four hours after their admission to the hospital. Plasma loss *per se* was found only in burns, crush injuries, gas gangrene, sepsis and gross contamination of the peritoneal or pleural cavities.<sup>4,5</sup> In the latter two categories plasma loss was often less than whole blood loss. Inasmuch as blood was not available except in exceptional circumstances at battalion aid, collecting and clearing stations, some of the most severely wounded casualties, or those in the most severe grade of shock from their wounds, were often given large quantities of plasma to render them transportable to the hospital. These casualties were frequently again in severe shock by the time they arrived at the hospital and further resuscitation was complicated because the remaining blood in their vascular tree was well diluted with plasma.

Among contributing factors in shock deaths are the following: (1) The use of large quantities of plasma to combat lowered blood volume when the loss has been of whole blood. (2) Unrecognized and/or uncontrolled continued bleeding. (3) Inadequate or poorly timed blood replacement with whole blood. (4) Delayed surgery in those cases in which there has been gross contamination of peritoneal and pleural cavities with contents of the gastrointestinal tract, or in which sepsis is developing. (5) Failure to recognize and/or control factors leading to cardiorespiratory embarrassment. (Included in this group are hemothorax, pneumothorax, cardiac tamponade, tracheobronchial obstruction from blood or mucus, painful chest wall wounds and gastric dilatation.) (6) Failure to control pain by morphine, novocaine nerve block, proper splinting of painful extremity wounds and timely surgery.

Table XI deals with the twelve leading causes of death, giving the percentage each comprises of the total deaths in the four periods studied. Neural trauma and/or intracranial hemorrhage or clot is second on the list and the immediate cause of death in 213 cases.

The relative importance as lethal factors of the brain damage produced by the missile and the damage produced by an expanding intracranial hematoma was often difficult to determine. It seemed unwise, considering the information available and our qualifications to evaluate it, to attempt to separate these cases into two groups. It may be mentioned here that only fifteen cases in which the principal wound was intracranial were listed as dying of shock. In 171 additional cases neural trauma and/or intracranial hemorrhage or clot was listed as a contributory or associated condition.

TABLE XI

THE LEADING CAUSES OF DEATH IN 1450 BATTLE CASUALTY DEATHS, SHOWING PERCENTAGE DISTRIBUTION BY PERIOD

	Jan-Mar. 1944	Apr-July 1944	Aug-Dec. 1944	Jan-May 1945	Jan-44 thru May-45
Total Cases	529	482	284	155	1450
Shock.....	34.6%	40.3%	32.0%	35.5%	36.1%
Neural trauma &/or intracranial hemorrhage of clot.....	12.3	13.7	15.8	23.2	14.7
Nephropathy.....	1.7	5.2	9.2	5.2	4.7
Peritonitis.....	2.5	5.4	6.7	4.5	4.5
Clostridial myositis.....	6.5	2.3	1.4	0.6	3.5
Pneumonia.....	2.6	1.2	6.0	3.9	3.4
Fat embolism.....	0.9	1.9	3.2	2.6	1.9
Thrombotic embolism.....	0.9	2.5	0.4	1.3	1.4
Spinal cord trauma.....	1.1	0.2	2.1	1.9	1.1
Tracheo-bronchial obstruction aspirated vomitus.....	0.6	0.2	1.1	2.6	0.8
Tracheo-bronchial obstruction, blood & mucous.....	0.2	0.8	1.1	1.9	0.8
Cerebral ischemia.....	0.4	0.2	0.7	1.9	0.6
Total.....	64.3%	73.9%	79.7%	85.1%	73.5%

Third in the list of causes of death is nephropathy. This category includes all those cases in which the cause of death was known to be due to a lower nephron nephrosis or pigment nephropathy. Included in this group are a few cases in which mismatched blood transfusions produced the lesion. Also included are a few cases in which sulfonamides were rather definitely the etiological agent. In the vast majority of cases, however, neither of these factors could be definitely named as the cause of the nephropathy. A great deal of work was done on this problem by the Commission for the Study of the Seriously Wounded organized by Col. E. D. Churchill and headed

by Lieut. Col. F. A. Simeone. Their extensive investigations would tend to indicate that neither blood transfusion nor sulfonamides are directly responsible for most of the cases but that some other factor, or factors, dependent upon a severe degree of shock over a long period of time was responsible.<sup>5</sup> For a time there was a tendency to limit the quantity of blood given the battle casualty in shock because of the fear of this complication. However, it was soon apparent that some lives would be lost from shock if the amount of blood used were restricted. The general feeling in the latter months of the war was that in shock due to lowered blood volume from whole blood loss whole blood replacement should be carried out as rapidly and as completely as possible regardless of the quantity of blood necessary to accomplish this purpose. The giving of low titer\* Group O blood to Group A recipients was thought for a time to be a factor. Subsequent investigations failed to confirm this suspicion. The number of cases in the various blood groups, paralleled the normal incidence. One case, a patient of Major James M. Mason III, suffered a left thoracoabdominal wound which necessitated removal of the spleen and of the left kidney. This Group A recipient received 5,500 cc. of low titer Group O blood before and during his surgery. There were no complications in his one remaining kidney, and he made an uneventful recovery.

Peritonitis was fourth in the list of the causes of death. In studying Table XI one sees that it comprises a larger percentage of the total deaths in the second and third periods covered by the study. This apparent increase can be explained in part by the reduction in mortality from Clostridial myositis, extremity wounds and unclassified wounds in the course of the four periods covered by the study. The apparent increase may also be attributed in part to the increase in the number of postmortem examinations so that peritonitis was more frequently recognized in the latter months.

Fifth in the list of causes of death is Clostridial myositis. In the first period under study Clostridial myositis accounted for 6.5 per cent of all deaths. This represented 0.28 per cent of all battle casualty admissions. In the last period these figures had fallen to 0.6 per cent of all deaths and only 0.094 per cent of battle casualty admissions. There were a number of factors operative in this reduction of mortality from gas gangrene. The educational program concerning Clostridial myositis and study of the problem conducted by

\* Group O blood in which anti A and anti B agglutinins are present in a titer of less than 1 to 64.

Maj. Floyd Jergesen and Lieut. Col. F. A. Simeone are probably chiefly responsible. Other factors are, more complete surgery on all wounds, the more liberal use of blood and the advent of the extensive use of Penicillin. With this reduction in mortality from Clostridial myositis or gas gangrene came a corresponding reduction in the incidence of the infection.

Pneumonia ranked sixth in the list of causes of death. The only striking variation in mortality from pneumonia is in the April through July 1944, period in which pneumonia comprised only 1.2 per cent of the deaths studied as compared to the average of 3.4 per cent for all four periods. It is the only one of the four periods which did not include winter months.

Attention is directed to the incidence of fat embolism. This diagnosis was not recorded except when microscopic reports indicated large amounts of fat in the pulmonary sections and the record indicated a clinical behaviour justifying the diagnosis. We were not aware of the comparatively large incidence of fat embolism until Lieut. Col. Tracy B. Mallory called our attention to the incidence of this complication. He reported the finding of fat globules in lung sections in nearly all cases in which there had been a fracture of a bone incidental to a wound. The finding of fat in lung sections was not regarded as significant unless the fat was present in large quantities. In addition to the twenty-seven patients who are listed as dying of fat embolism there were twenty-two others in which the diagnosis of fat embolism was evident but in which it was listed as a contributory condition rather than the immediate cause of death.

Thrombotic embolism ranks eighth in the list of the causes of death. There are only twenty cases in all in which this complication was assigned as the immediate cause of death. Three of these occurred in the last two periods covered by the report. An effort was made to prevent deaths from thrombotic embolism by early recognition of phlebothrombosis in the lower extremities and by prophylactic ligation of the superficial femoral vein or common iliac vein in these cases. Thrombotic embolism was particularly common in cases of Clostridial myositis. In those cases in which clots were found in the veins at the level of amputation for Clostridial myositis, it became common practice to do a ligation above the clot as a prophylactic measure. Some of the early deaths that occurred in patients with gas gangrene occurred after symptoms of the disease itself had disappeared and thrombotic embolism developed as a late complication.



Sixteen deaths in all were attributed to spinal cord trauma. In nearly all of these a high cervical lesion was present.

Tracheobronchial obstruction from aspirated vomitus and blood and mucous contributed twenty-two deaths in all. Tracheobronchial obstruction from aspirated vomitus was quite common in all sorts of wounds. Early in the campaign it became routine to pass a nasogastric tube on all those with abdominal wounds. This later was extended to chest wounds and before the end of the war there were many who had the feeling that a nasogastric tube should be passed in all patients who had been in shock. When aspiration of vomitus occurred, bronchoscopic aspiration was done in most cases.

Tracheobronchial obstruction from blood and mucous occurs not only with chest wounds but frequently in head wounds, maxillofacial wounds and cervical wounds. The importance of repeated tracheal aspirations with a tracheal catheter became common knowledge. In those cases which could not be controlled by cough or tracheal catheter, bronchoscopic aspiration was performed.

Cerebral ischemia was assigned as the immediate cause of death in eight cases. In all of these cases there was a laceration of one of the carotid vessels. Cerebral damage due to cerebral ischemia resulting from prolonged shock was conspicuous by its absence.

#### SUMMARY

Data are presented on the number of men dying on the battlefield as compared to those who die after they reach a hospital. The inverse variation in these two figures is demonstrated. Data are then presented on 86.5 per cent of all the American battle casualty deaths occurring in Fifth Army Hospitals in Italy from January 1, 1944, to May 2, 1945. A classification of these cases as to location of principal wounds and as to immediate cause of death is made. The importance of shock, neural damage, kidney complications, lung complications, embolism and other factors as immediate or precipitating causes of death is elaborated.

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## DISCUSSION

RONALD N. ADAMS (Boston): Dr. Snyder's very comprehensive paper certainly covered a lot of territory, much of which would be open for further fruitful discussion. I will confine myself to one point only. I am sure if he had had the time he would have spoken further on pigment nephropathy. It might be of interest to you to let you have the clinical side as we saw it working in the field hospitals overseas.

First of all, it was a new clinical entity to us. These patients, very seriously injured, would get by their operative phase and in three or four days would develop an anuria, death occurring four or five days later. Remember that when we were working we did not have the benefit of some of the knowledge we now have of this state, which I believe was first ably written upon by Dr. Bywaters and his group in England studying the crush syndrome of patients injured in air raids there. Since that time a voluminous literature has grown up on this particular phase of the subject.

We were presented with these patients and the new clinical entity that we didn't know a thing about and we were called upon to treat these patients. In 1943, of course, we were conversant with the sulfa drugs and the reactions to them. First of all, the toxic and perhaps allergic state with edema of the tubules and consequent aneuria. Also, of course, the mechanical factor of a blocked renal pelvis due to a crystalluria.

We imagined these patients were suffering from this particular trouble, since all the patients routinely had sulfadiazene therapy. We studied our patients from this point of view. Many patients developed crystalluria who never got into trouble at all. Some of the anuric patients we did have, were sent on to evacuation hospitals and general hospitals for further study, the kidney pelvis washed out, and in surprisingly few instances was a really blocked ureter ever found.

So we turned our attention to the factor of blood. These patients, of course, had large quantities of blood. Much of it was several days old, I should say on the average the blood was ten to fourteen days old when we used it. Part of it may have been partially hemolyzed and later on, as we studied the blood, we found some bacteria from contaminants and therefore we wondered if we were giving too much blood to these patients and thus multiplying the possibilities of blood reaction.

We had a blood study conducted by doctors from the Fifth General Hospital and they came to our field hospitals and saw these patients and checked up scientifically on the blood which we were giving them. Their report was that we were using too little rather than too much blood for these badly shocked patients. Furthermore, while we did get some reactions to the blood, there were relatively very few deaths actually attributable to blood reaction.

Therefore, we turned our attention to some other phase of this problem

and we thought that by alkalizing our patients we would get them away from this syndrome of anuria. We would give soda bicarbonate by mouth and calcium lactate intravenously and although we put some of our patients on the verge of alkalosis with muscle spasm and all that goes with it, we seldom succeeded in getting the urine alkaline. We found that it made very little difference to our patients eventually whether they were alkalyzed or not, as far as death from this pigment nephropathy was concerned.

At the end of the war we have the excellent studies of Tracy Mallory in the pathological end of this particular problem, not yet published, but I heard him speak on the subject, about a month ago and certainly it has been studied extensively in the British and Australian armies. We have a fairly detailed knowledge of the pathological problems involved.

At the present time our clinical experience has not told us what we can do to avoid this very painful and highly mortal syndrome. I hope that in the next few years perhaps we can find something more to combat its devastating effects.

# ABDOMINAL TRAUMA

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**A**BDOMINAL injuries, although not uncommon in civilian practice, are of such greater frequency in warfare that a considerable and worthwhile experience with them may be gained. The mere fact that the commonest etiological agent is a shell fragment in war, rarely seen in civilian experience, is of no great consequence since the pathology, management and prognosis do not differ in essential respects regardless of the causative agent. Neither can data from war wounds of the abdomen be discredited, in their application to civilian practice, because of such factors as time-lag and battle field contamination since they, too, are relatively unimportant.

TABLE I

CAUSATIVE AGENT AND RELATIONSHIP TO MORTALITY IN 393 CASES WITH ABDOMINAL INJURY ADMITTED TO AN EVACUATION HOSPITAL

Wounding Agent	No. Cases	Incidence Per Cent	Mortality Per Cent
Shell fragment.....	260	66	20
Bullet.....	94	25	18
Mine fragment.....	17	4	30
Bomb fragment.....	2	.5	0
Stab Wound.....	5	1.5	0
Subparietal.....	15	4	20

This report is based on an experience in an Evacuation hospital during the Italian campaign and, after the end of the war, a comprehensive review of abdominal surgery in the Mediterranean Theatre. The Evacuation hospital series consisted of 412 cases with abdominal wounds of sufficient severity to require laparotomy, 358 of which have been previously reported.<sup>2</sup> The review for the most part consisted of 3,154 cases cared for by the 2nd Auxiliary Surgical Group which was composed of surgical teams working chiefly in Field hospitals.

*Time-lag.* As shown in Table II, there is little to indicate any great influence of the time interval between wounding and operation on the mortality rate. Certainly there is no "golden period"

for the care of abdominal injuries. It is well recognized, however, that patients do not withstand profound shock for many hours and to be effective, anti-shock measures must be instituted early. The important time interval therefore, appears to be from the beginning of shock to its alleviation. Random selection of records of eighty-four first priority cases revealed they received their first plasma infusion within 2.3 hours from time of injury; in 60 per cent of this group that interval was one hour or less. Thus, effective anti-shock measures were instituted earlier in war II than in previous wars and were undoubtedly a major factor in the improved results from surgical therapy.

TABLE II  
RELATIONSHIP OF TIME-LAG TO MORTALITY

Time Interval (Wounding to Operation in Hours)	Auxiliary Surgical Group (Chunn and Hauver) 1222 Cases with Wounds of Colon or Rectum		Evacuation Hospital (337 Cases with Abdominal Injury)			
			All Cases		Cases with Hollow Visceral Perforation	
	Cases	Mortality Per Cent	Cases	Mortality Per Cent	Cases	Mortality Per Cent
0-6	336	31.3	60	18	31	22
6-12	575	37.4	141	22	65	35
12-18	168	38.7	64	23	27	30
18-24	66	30.3	41	10	21	14
24-48	65	38.5	40	10	9	11
48-	12	25.0	22	31	13	46

*Resuscitation.* Since shock is so commonly associated with abdominal injuries and is the greatest single factor in the cause of death, its recognition and treatment before operative procedures are undertaken is imperative. Concealed hemorrhage and extensive peritoneal contamination greatly aggravate shock and render its evaluation difficult. It is a common observation that patients with extensive fecal contamination of the peritoneum exhibit a peculiar lack of response to measures of resuscitation.

Resuscitation consists for the most part of a restoration of the circulating blood volume by giving infusions of whole blood and plasma. It is generally appreciated that whole blood is more efficacious than plasma. The latter's principal use was in the Aid Stations where whole blood infusion was impractical. In Table III is shown the replacement therapy as used in a series of cases, reported by

Towery,<sup>7</sup> with varying degrees of shock and the mortality as related to shock.

The admission blood pressure serves as a criterion for the speed with which blood replacement is started and the amount given largely depends on the patients response. A stabilized blood pressure of 100 mm. of mercury is highly desirable and not uncommonly two or three thousand cc. of blood are given to obtain it. Occasionally there is no such satisfactory response particularly in those patients with massive intra-abdominal hemorrhage and an extensive fecal peritoneal contamination. In such cases operative measures are carried out without further delay simultaneously with further blood replacement.

TABLE III  
SHOCK, ITS TREATMENT AND RELATIONSHIP TO MORTALITY IN 957 CASES WITH  
GASTROINTESTINAL PERFORATIONS (TOWERY)<sup>7</sup>

Admission Systolic Blood Pressure (mm of Mercury)	No. Cases	Average Time—Lag in Hours. (Wounding to Operation)	Replacement Therapy (in cc.)						Mor- tality Per Cent
			Preoperative		During Surgery		Total		
			Plasma	Blood	Plasma	Blood	Plasma	Blood	
0-40	140	10.8	713	1745	311	1617	1024	3362	66.4
41-70	121	10.7	687	1271	311	1278	988	2549	50.4
71-100	250	11.6	602	873	261	1063	863	2036	38.0
101-120	446	10.4	492	619	178	962	670	1581	18.1

Early in our experience many patients with a satisfactory pre-operative blood pressure were subjected to surgery without previous replacement therapy. Not uncommonly there occurred a sharp fall in the blood pressure after the operation was underway, which always occasioned considerable disturbance in starting an infusion and often unduly hurried the operative procedure or made it's completion impossible. The latter was responsible for overlooking bowel perforations in a few instances and for many postoperative incidents resulting from the hurried and defective technic.

Emptying the stomach by use of a nasogastric tube facilitates resuscitation as well as the operative procedure. It is also an important measure in the prevention of pulmonary complications arising following aspiration of vomitus during anesthesia.

*Examination.* As the general condition of the patient permits a careful appraisal of the abdominal injury is made. Particular

attention is paid to the location, character and extent of the wounds. As regards penetrating wounds of the abdomen, it is noteworthy that 20 per cent were so located as to involve the thorax, and 10 per cent the buttocks. Too, the likelihood of subparietal wounds must always be considered. There were fifteen instances of subparietal injuries in the E.H. (Evacuation Hospital) series of 412 cases.

Abdominal tenderness and rigidity usually indicate peritoneal irritation from either blood or intestinal contents. Those findings are not uncommonly observed, however, in injuries involving only the thorax, abdominal wall, spine or bony pelvis. Audible peristaltis on auscultation is highly indicative of an intact peritoneum; its absence, however, isn't as reliable an indication of peritoneal penetration.

Routine urinalysis often yields a clue to an otherwise unsuspected injury of the urinary tract. Similarly, examination of the rectum is a most worthwhile measure in detecting injuries of that viscus.

When the patients condition permits, roentgen examination is made in both A-P and lateral projections. The finding and localization of a foreign body is of great aid in determining whether or not there is actual peritoneal penetration and if so, what viscus is involved so the operative procedure may be planned accordingly. The finding of free gas in the abdominal cavity is a well recognized indication of gastrointestinal perforation.

*Operability.* The Theatre policy was such that every casualty which survived a few hours intensive resuscitation was given the chance for recovery that surgery afforded. The acceptance of all risks necessarily contributed to the operative mortality rate, which was essentially that of the hospital death rate. This policy is an important consideration in the comparison of operative mortality rates with other reported experiences in which it did not obtain.

In the E.H. series of 412 cases there were eight deaths before operation could be undertaken, an operability rate of 98 per cent; in an A.S.G. (Auxillary Surgical Group) series<sup>3</sup> of 547 cases there were thirty-six without surgery, an operability rate of 94 per cent.

*Anesthesia.* Ether is the anesthetic agent of choice and its administration with a closed system through an endotracheal tube is highly desirable. That manner of administration permits an uninhibited respiratory exchange, facilitates upper abdominal procedures, permits easier turning of the patient for the care of back and extremity wounds, permits the use of positive pressure for the care of

associated thoracic injuries, and reduces the likelihood of aspiration of foreign material as well as permitting frequent removal of tracheobronchial secretions by catheter aspirations.

*Operative Approach.* The following factors determine the placing of the incision: (1) Probably intra-abdominal injury. (2) The site of missile wounds. The operative incision should be removed from those wounds. (3) A coexisting chest injury often makes a transthoracic approach desirable. (4) Preservation of neurovascular structures in the abdominal wall often determines the type of incision in instances in which other considerations are equal. (5) Preservation of a portion of the abdominal wall well away from the primary incision through which, if required, an injured segment of colon may be exteriorized.

Vertical abdominal incisions, mid-line or paramedian have obvious advantages particularly if the extent of the intra-abdominal injury is unknown. Subcostal and transverse incisions afford excellent exposure of the upper abdominal quadrants but make difficult the use of the lateral abdominal wall for well removed secondary incisions for exteriorization of a colonic segment. Transthoracic approach not only permits thorough care of associated chest injuries, but affords greater facility for the care of upper abdominal and diaphragmatic injuries.

*Visceral Involvement.* The mortality rate from abdominal wounds is directly proportional to the extent of visceral injury. The number of viscera involved is admittedly not an altogether accurate index of the extent of the injury, but in practice it is representative. Of 330 cases of the E.H. series, 30 per cent had multiple visceral injuries with a mortality rate of 40 per cent; whereas in 70 per cent with a single viscus involved the rate was 10 per cent. As shown in Table IV, that relationship is apparent for each viscus. In the larger A.S.G. series<sup>8</sup> there was a progressive rise in the mortality rate for each additional viscus injured.

*Operative Management of Specific Visceral Injuries.* Most wounds of the stomach permit closure by simple suture. In seven instances of the A.S.G. series the wounds were so extensive that resection was done.

Duodenal injuries require mobilization of the viscus so that repair can be accurately affected without too great tension resulting on the suture lines. Failure to adequately mobilize the duodenum for finding and satisfactory closure of wounds will result in fistula with its disastrous consequences.



Wounds of the small intestines can be satisfactorily closed by simple suture in the majority of instances. In the more extensive wounds, however, resection and end to end anastomosis is frequently indicated. The hazard of the latter procedure, as shown in Table v, appears less real than heretofore believed, when the extent of visceral injury is considered. Exteriorization of the small intestine should not be done.

TABLE IV  
THE RELATIONSHIP OF EXTENT OF VISCERAL INJURY TO MORTALITY

Viscus	One viscus injured			Two or more viscera injured		
	Cases	Deaths	Mortality Per Cent	Cases	Deaths	Mortality Per Cent
Stomach.....	3	0	0	20	10	50
Duodenum.....	1	0	0	10	7	70
Small intestine.....	56	7	12	47	21	44
Colon.....	38	3	8	52	24	46
Rectum.....	31	2	6	14	5	36
Liver.....	45	5	11	33	14	42
Gall bladder.....	0	0	0	5	2	40
Pancreas.....	2	0	0	11	4	36
Spleen.....	21	4	19	23	14	60
Kidneys.....	14	2	14	35	17	49
Bladder.....	7	0	0	10	2	20

TABLE V  
THE MORTALITY RATE FOLLOWING OPERATIVE PROCEDURES FOR WOUNDS OF THE SMALL INTESTINE IN CASES WITH AND WITHOUT ADDITIONAL VISCERAL INJURY

Procedure	No. Cases	Mortality Per Cent	Incidence of Multiple Visceral Injury Per Cent
Suture.....	76	23	40
Resection.....	27	33	60

Since much of the colon is relatively fixed and inaccessible as compared with the small bowel, the finding of all perforations and their accurate closure without tension is fraught with considerable possibility of failure. Too, the injured colonic segment may be exteriorized without great physiological disturbance. As a result, most wounds of the colon in War II were exteriorized. It is certainly the procedure of choice for an extensively damaged colonic segment and particularly if its blood supply is questionable. In the cases with less extensive injury, however, primary suture of the colon

may be satisfactorily accomplished with far less morbidity resulting than if exteriorized. The procedure to be employed therefore should largely depend on the extent of the injury. As shown in Table vi, primary suture appears actually less hazardous than exteriorization, but that advantage is more apparent than real since the extent of the injury is the major lethal factor. The safety of primary suture in selected cases is also shown by a mortality rate of 24 per cent in 168 cases (from the review of Theatre experience) so managed, contrasted with a rate of 35 per cent in 945 cases that had exteriorizations. The risk from primary suture compares favorably, too, with the mortality rate of 22 per cent in 321 cases in which the colon alone was involved without regard to the operative procedure. Resection of a traumatized colonic segment and immediate anastomosis is a too formidable procedure for a patient whose injury might appear to indicate it.

TABLE VI

THE RELATIONSHIP BETWEEN OPERATIVE PROCEDURE AND MORTALITY RATE IN EIGHTY-SEVEN CASES WITH COLONIC INJURY

Procedure	No. Cases	Deaths	Mortality Per Cent	Incidence of Multiple Visceral Injury Per Cent
Exteriorization.....	62	21	34	70
Suture.....	6	1		
Suture with proximal colostomy.....	5	2	12	30
Suture with proximal tube colostomy.....	14	0		

Wounds of the extraperitoneal rectum are best managed with a sigmoidostomy to divert the fecal stream and drainage of the retrorectal space through a postanal incision.

Wounds of the liver are occasionally the source of considerable hemorrhage, however, by the time the patient comes to operation it has usually ceased. In the event it persists it is best controlled by packing lightly with gauze. Suture of the liver is for the most part ineffective. All liver wounds of consequence should be thoroughly drained, preferably through a separate subcostal incision. Loose fragments of liver are removed. Foreign bodies embedded in the liver are removed only if they are easily accessible.

Pancreatic injuries are drained. Rarely, however, is there drainage of consequence except when one of the main ducts is involved.

The traumatized spleen should receive priority over other visceral wounds at operation. Its tendency to bleed profusely

immediately and delayed makes splenectomy the procedure of choice. Occasionally, if the wound is slight, it may be left alone. Since approximately two thirds of the cases with splenic injuries from penetrating wounds have associated thoracic injury, a trans-thoracic approach to the spleen is frequently desirable. It was employed in approximately one half of 407 collected cases without an increase in operative mortality resulting.

TABLE VII

CHEMOTHERAPY AS APPLIED TO 268 CASES WITH PERITONEAL PENETRATION, 170 OF WHICH HAD GASTROINTESTINAL PERFORATIONS, AND THE MORTALITY RATES

Drug	Route of Administration	All Cases	Deaths	Cases with Hollow Visceral Perforations	Deaths from All Causes	Deaths from Peritonitis	Preventable Deaths from Peritonitis
Sulfonamides	Topical, intravenous and oral	69	14	58	13	4	2
Sulfonamides	Intravenous and oral	43	2	16	2	2	1
Sulfanilamide and penicillin	Topical and intramuscular	62	9	54	9	3	1
Penicillin.....	Topical and intramuscular	13	5	9	5	2	2
Penicillin.....	Intramuscular	81	13	33	10	2	1
Totals		268	43-16%	170	39-23%	13	7

Conservation of the injured kidney is desirable whenever feasible. Only if it is extensively shattered or it's pedicle injured is nephrectomy employed. In approximately one fourth of 531 collected cases the injured kidney was removed.

Bladder injuries are satisfactorily managed by a high cystostomy and drainage of the space of Retzius.

*Chemotherapy.* Since the advent of the sulfonamides and penicillin, chemotherapy has been widely used in the treatment of abdominal trauma. It's true efficacy is as yet undetermined, but a decided impression prevails that it is beneficial. Whenever the patient survives for a sufficient period to receive adequate chemotherapy, rarely does death result from spreading infection. Localized infections appear to occur with undiminished frequency in spite of chemotherapy. In Table VII is shown the results from chemotherapy as applied to 268 cases with proven peritoneal penetration, 243 of

which have been previously reported.<sup>3</sup> There were thirteen deaths from peritonitis, four of which had a diffuse suppurative process at operation, one an overlooked perforation and one in severe shock surviving only seventy-two hours following operation. Seven cases were considered possibly amenable to chemotherapy but failed to survive in spite of it.

TABLE VIII  
ANALYSIS OF CAUSE OF DEATH IN THREE SERIES OF ABDOMINAL CAUSALTIES

Primary Cause of Death	A.S.G. Series I (346 Cases) <sup>5</sup>	A.S.G. Series II (3154 Cases) <sup>6</sup>	E.H. Series (412 Cases)	Total (3892 Cases)	Per Cent Total
	No. Deaths	No. Deaths	No. Deaths	No. Deaths	
Shock.....	30	491	38	568	60
Pulmonary Complications.....	24	97	7	128	13.6
Peritonitis.....	7	91	13	111	11.8
Anuria.....	5	35	2	42	4.4
Associated injuries, extraperitoneal infection, anesthesia, duodenal fistula, intestinal obstruction, etc.....	30	42	18	90	10
Total.....	105	756	78	939	
Mortality %.....	30.3	24.	18.9	24.1	

*Mortality.* As shown in Table VIII, 60 per cent of the deaths were directly attributed to shock and in many attributed to other causes it was a major factor. Early and effective resuscitation enabled many of the severely wounded to reach a hospital and undergo an operation, but necessarily resulted in an increased hospital mortality rate.

Pulmonary complications leading to death were largely atelectasis, pulmonary edema, pneumonia and infarction. They were responsible for 13.6 per cent of the deaths in spite of all the customary precautions and remedial measures, including chemotherapy, which were used.

Peritonitis was considered primarily responsible for 11.8 per cent of the deaths. It was admittedly a factor in many of those attributed to shock. In fact, most patients dying within the first forty-eight hours suffer from shock, early peritonitis, and pulmonary edema. It is obviously impossible to accurately evaluate the importance of each factor. In defense of peritonitis as the major

factor, however, were the severely wounded without intestinal perforations whose clinical course was indistinguishable from those who had some peritonitis and of 580 cases with either the colon or small intestines injured alone, all with varying amounts of fecal contamination, but with a minimal degree of shock, there were few deaths from peritonitis within the first forty-eight hour period.

#### SUMMARY

1. The degree of shock is in direct ratio to the extent of the injury represented by the number of viscera involved. Although shock remains the most important factor in the mortality, the recognition of its importance and the emphasis placed on resuscitation in War II were largely responsible for the improved results.

2. The factors of wounding agent, time-lag, principal viscus involved, and technical procedures employed appear relatively unimportant.

3. Chemotherapy appears to have favorably influenced the factor of infection in the mortality.

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#### DISCUSSION

R. ARNOLD GRISWOLD (Louisville, Ky.): I believe you all realize what an excellent paper Dr. Imes has just presented. It points out the things we can learn from military surgery.

In Louisville General Hospital we have what we think are quite a number of gunshot and stab wounds of the belly. I think all large southern general hospitals have them. We have (we have always thought) about as many as any hospital in the country, but it took us a little over ten years to collect a series of 400 cases. Dr. Imes collected a series of 400 cases in just a couple of years.

In most of the large civilian series of gunshot wounds of the belly the mortality runs in the neighborhood of 50 per cent. Dr. Imes has shown us

400 odd cases with a mortality rate of under 30 per cent. Why is that? Some reasons have been given. One is that the man who has a serious wound, dies of hemorrhage before he ever gets to a hospital. In a large city the man gets to a hospital within thirty minutes.

That, however, is not always the story. Another excuse given for the comparative high mortality in civilian hospitals is that the military surgeon was dealing with patients in better physical condition. That statement is not true. Originally those patients were in better physical condition; they are younger, huskier but they have been exhausted. In many cases they are starved and dehydrated. Often they have lain on the battlefield in inclement weather for a varying period of time, so they are not as good a surgical risk as the patient we see in a civilian hospital with a gunshot wound of the belly.

Why are Dr. Imes' statistics better than the ones we see? There are several reasons. First, the large amount of blood used in resuscitation. Too often in civilian practice we give a patient a 500 cc. transfusion of blood and think we have given him a transfusion; 500 cc. of blood is a donor's dose and has nothing whatsoever to do with what the recipient needs.

The one lesson learned in the war is to give the patient the amount of blood needed to restore his physiology.

Anesthesia is another factor. It has enabled surgeons in the army to do transthoracic explorations of the wounds of the upper belly, which is the approach of choice if you have a competent anesthetist.

Another factor is better surgery performed up front in this war. That comes back to several factors. First, this war has shown the results of the residency system of training surgery in this country. We had large numbers of competent surgeons who came up through the residency system, who were able to go forward and do the kind of surgery that Dr. Imes has done.

Another factor is the thing that our President brought up in his address this morning, the result of a consultant system which functioned not only in this country but overseas, where men like Howard Snyder, Cutler and Churchill, were correlating the procedures, seeing that they were carried out and were seeing that the right man was in the right place to do surgery.

# OBSERVATION ON THE MANAGEMENT OF BURNS

CAPTAIN H. L. D. KIRKHAM  
MEDICAL CORP, UNITED STATES NAVAL RESERVE

**D**URING the past three and one half years at the San Diego Naval Hospital we have seen approximately 1700 burn cases, both acute and in the later stages needing plastic repair. It is the purpose here to give you some general observations that were noted in this rather large series of burns.

The management of burns can be divided into three phases (1) the general treatment of the burn patient (2) the local treatment of the burn (3) a later plastic repair of existing deformities.

In October, 1943, we admitted fifty-nine Marines who had been burned in a forest fire in the San Diego area. These burns were incurred the day before admission and were given first aid treatment as far as possible at the station hospital Camp Lockett, U.S. Army. The treatment there consisted of dried plasma in amounts of 500 to 7000 cc. per case the total being 50,500 cc. Morphine was given together with sulfathiozole parenterally and orally, sulfathiozole ointment and in a few cases tannic acid tanning had been used. After admission to the Naval Hospital immediate complete blood counts and hematocrit reading were taken together with an estimate of body surface burned by the Berkow method and haemoglobin reading were made. The reason for this was to try to establish whether or not either of these methods of determining the amount of plasma needed in a given case was more accurate than the others. The results showed that there was practically no difference in the plasma requirement in any one of these three methods. In the final analysis either one of these methods we considered should be used as a rough guide, but clinical observation of the patient was of more importance.

These burns were second and third degree, and the areas most commonly burned were the hands, usually both, the face, arms, thighs and backs.

Plasma therapy was instituted at once on admission and according to the needs of the individual patient 37,000 cc. were used in the first week. A few of these during this time were given whole blood

transfusions and invariably a reaction occurred and their blood concentration increased. The second day after admission all cases were re-dressed under morphine sedation were gently debrided and hypertonic saline wet dressing and bath treatment was begun. Two weeks later fourteen cases were further debrided in surgery under sodium pentathol anesthesia and these cases were the ones who had had tannic acid applied.

From October third to November 30th all cases progressed satisfactorily under hypertonic saline treatment. On December the first case died suddenly of pulmonary embolism from thrombosis of the left iliac vein. Fifty three cases were returned to duty by December 9, 1943. The remaining five were hands to which tannic acid had been applied.

The general treatment of the burned patient has become more or less standardized. Practically every recent article will suggest the internal and local use of sulfa drugs, but this opinion does not coincide with our observations. All burns, if at all severe, will develop a certain amount of anemia and blood concentration. It has been shown that in burns of 31 per cent of the body surface 25 per cent of which are third degree the red cells are destroyed at the 94.5 cc. of packed cells per day during the first  $4\frac{1}{2}$  days. In the next three days a red blood cell balance occurs with a gain of about 14 cc. per day. On the 7th day red blood cells are destroyed rapidly, about 190 cc. per day, probably due to infection. From the 14th to the 33rd day the rate of destruction is less than 85 cc. After this the red blood cell formation is more rapid than their destruction. It is well known that sulfa drugs show greater absorption from a burned surface than from a clean granulating wound and often this absorption is delayed and an accumulative action is produced which tends to increase the already existing anemia. Our observations in this series showed that anemia was more marked in those cases in which sulfa had been used generally or locally and that its use had no effect on subsequent infection. It was also observed that the giving of whole blood in the early stages gave more reaction and at the same time increased hemoconcentration. We have therefore felt that it is not advisable to give whole blood until after the first week or ten days.

A discussion of the local management of burned surfaces brings up a great divergence of opinion, and is approached with fear and trepidation. At the time of Pearl Harbor most of the burns were treated with tannic acid or tannic acid jelly, this being the routine agent on the Navy supply table. Members of the Research Council



present in Pearl Harbor at the time returned very enthusiastic in their praise of tannic acid and some were advocating it as the standard approved method of treating war burns. Later the Coconut Grove fire occurred and these burns were practically all treated by the Koch method of vaseline gauze and pressure dressings. The results were quite good and this method of treatment was hailed by many as the millennium. While this method was given a trial at San Diego we could not feel that it had any particular advantage over the open treatment with hypertonic saline solution because by the latter treatment we were able to skin graft them at a much earlier date for it is well known that skin grafts do not take well on a greasy surface. Neil Owens in searching for a compromise between the saline dressings and the principle of pressure has suggested the use of rayon covered with pressure dressings, the rayon being used wet or dry. This method has been very successful in our hands, and has the added advantage of being very comfortable for the patient.

All of these more or less standard methods of treatment tend to show that the local management of burns must be based on sound surgical principles rather than upon the use of specific drugs, preparations or agents. We have felt that a burn should be considered as an open surgical wound, which is potentially infected, and should be basically treated as such. This is accomplished by very careful primary cleansing and thereafter keeping it as clean as possible, and it matters little what is used to accomplish this end. It is also felt that the original cleansing of the burned area by the gentle use of white soap and water, using wet cotton and the removal of loose tissue is the most important of local burn treatment.

It is generally conceded that tannic acid should never be used on the hands, face or genitalia, and probably the only situation where its use can be considered is in severe burns of the back which seldom need skin grafts and by this means the patient is given a covered surface to lie on.

It must be borne in mind that the electrical burn is vastly more destructive especially to bone tissue, than the ordinary thermal burn. In some instances the bone destruction opens up more plastic problems than the destruction of the soft tissues.

All burned areas which will produce contracture should be skin grafted as soon as they are clean, probably the most universally satisfactory graft is the so-called "thick split graft." The only mention that need be made of the Riverdin or pinch graft is to completely condemn it in all cases and under all circumstances. Cases

which have healed and produced contracting bands can often be completely corrected by the use of the so-called Z plasty provided the tissue on either side of the contracting band is reasonably good. It is felt that these two plastic procedures, namely the use of the thick split and the principles of the Z plasty should be the only procedures attempted outside of a plastic center. A case which needs more reconstructive surgery immediately becomes a plastic problem which needs very careful planning from beginning to end. These remarks are made with great personal feeling having seen many burned patients returned from the combat zone upon whom some haphazard repair had been attempted much of which was wholly inadequate to repair the defect with the result that much time was consumed in undoing what had already been done before the definitive repair was attempted.

#### CONCLUSIONS

1. Sulfa drugs locally or orally are of no benefit but are rather a detriment.
2. Blood transfusions are of more value after the 7th day.
3. In estimating the needed plasma dosage there is practically no difference in estimations made by the Berkow Method of body surface, hemoglobin estimation or Hematocrit readings.
4. In the local treatment sound surgical principles are more important than specific agents or measures. Tannic acid should not be used especially on the face, hands, or genitalia.
5. Skin grafts from one individual to another, especially close relatives, while never permanently successful as such, are sometimes life saving in extensive burns to prevent loss of body fluids, and tide the patient over the early critical ten days.
6. The late reconstructive repair of extensive burn deformities and contractions should be handled in a plastic center.
7. Burns should be regarded as an open surgical wound potentially infected and should be treated as such by getting it as clean as possible and keeping it in this condition, by the agent or method proved most successful in individual hands; bearing in mind that early skin grafting of areas, especially those liable to produce contractures is most desirable and essential.

#### DISCUSSION

NEAL OWENS (New Orleans, La.): I wish to give my support to the statements of Captain Kirkham made relative to the general treatment of

burns. The major importance of this was the application of sound surgical principles. It is the application of these principles that determines the outcome of any burn, with a minimal response in complications.

As Captain Kirkham stated regarding rayon, the dressing was developed in an effort to find some covering for wounds which would be a compromise between the accepted method of using greased dressings adjacent to the wound beneath pressure dressings. Pressure dressings, I believe, have been accepted for a considerable number of years; I know they have been used on the Tulane Service in Charity Hospital for eight to ten years. We feel that rayon adjacent to a wound gives the best response in wound healing associated with this method of treating burns. We have never accepted the principle of using greased dressings in contact with wounds, because they prevent drainage which is so necessary.

Fine mesh gauze has been widely used in an attempt to develop a dressing which would permit drainage. The open weave of the gauze mesh, however, permitted entrance of capillaries into the substance of the dressing, which in turn reflected pronounced bleeding along with a reflection of pain when dressings were changed.

We believed that the ideal material was one that would be sufficiently fine in its weave to prevent the entrance of capillary buds of 8 to 9 microns, and at the same time allow for necessary drainage. Rayon cloth having a weave of  $114 \times 114$  is the material that gave us the nearest answer.

The idea seems prevalent that rayon of unspecified weave is proper to use. I do not concur in that opinion, as the weave should be accurate in order to prevent the penetration of capillary buds and allow for adequate drainage. When too large a weave of rayon is used, bleeding takes place at every dressing change. The capillary buds which have penetrated this large weave are torn and hence there is an unnecessary loss of blood.

Unnecessary bleeding is of tremendous importance when one considers that as much as 200 to 400 cc. of blood can be lost from granulations when changing dressings on severely burned patients. The loss of 200 to 300 cc. of blood from an extensive burn on a young child is a matter of grave consideration.

Dr. Mayerson of the Department of Physiology at Tulane University, while performing experiments on dogs, showed that tilting the animals to an upright position with their feet down made them extremely susceptible to hemorrhage. The removal of from 10 to 15 cc. of blood from these animals precipitated irreversible circulatory failure. When one considers that a small baby has practically the same amount of blood as a dog of moderate size, it becomes apparent that the loss of 200 to 300 cc. of blood during a dressing change is of considerable importance. The growing realization of the need for tremendous quantities of whole blood in the treatment of burns, makes it more urgent than ever that the unnecessary loss of blood at dressing changes be abolished.

If the rayon material is used under a continuously moist dressing, which we frequently use in the treatment of infected wounds, it does not become adherent and is easy to remove. When used in connection with dry dressings, as in the treatment of uninfected burns, the dry sebaceous material in contact with the rayon will become adherent. The dressing may be easily removed by moistening it with saline or preferably a little ether.

Rayon 114 × 114 weave and moistened with saline is an ideal dressing. It allows for adequate drainage, does not permit capillary penetration, and has the lowest coefficient of friction of any dressing we have used.

CHAIRMAN HEGNER: Dr. Kirkham, have you any other remarks?

HAROLD KIRKHAM: No, thank you.

PRESIDENT PENBERTHY (closing): I am back simply to congratulate Captain Kirkham on his positiveness and his statements emphasizing the sound surgical principles in the treatment of burns. I think that is important; and further, as Captain Kirkham implied, each individual case becomes a case within itself.

In his presentation Dr. Kirkham confined himself largely to the surgical management of burns. I wonder if he would enlarge a little on dietary measures. That is, in that group of Marines he treated, who were severely burned, what it did in the way of combatting hypoproteinemia; further, what was done in the way of maintaining a caloric diet and how it was regulated.

It is most important, in the type of burn that Captain Kirkham referred to, that we have something added to what he so beautifully presented in the way of the surgical treatment of burns.

## DISCUSSION BY DR. L. H. McKIM ON THE MILITARY PROGRAM

I wish to thank the chairman, Col. Penberthy, for the privilege of appearing in the discussion of this very important program. I will confine myself mainly to a few remarks on the paper by Capt. Kirkham on 'The Management of Burns.' The slides I will show are from the Departments of Surgery and Pathology, The Montreal General Hospital, and represent some work carried out by our pathologist, Dr. J. E. Pritchard in conjunction with burn and plaster trams.

These illustrations\* represent a series of biopsies on various stages of burns and skin grafts. It is our belief that a careful study of burns by the biopsy method is of great value as a guide in the treatment and management of burns of any severity.

The first illustration was a diagrammatic representation of the various layers showing the depths of the skin and its appendages in various parts of the body. It demonstrated the deep penetration of the hair follicles in the scalp, face and scapular regions, also their entire absence on the palm of the hand.

The second slide was that of a superficial burn of twenty-four hours' duration. It showed the superficial layer of the keratin with slight separation at each end of the section. The epidermis was thickened by edema and partly separated but in certain areas a small portion remained and at the left margin of the slide there was a viable hair follicle and sebaceous gland. This burn will undoubtedly heal rapidly and without scar tissue formation if infection is prevented.

Slide three was that of a slightly deeper superficial burn on the fifth day. It demonstrated the coagulated exudate on the surface, also the regeneration by creeping of the epithelium across the burned area.

The fourth illustration was that of a somewhat deeper burn on the twenty-sixth day showing the regeneration of epithelium from a hair follicle on the left of the slide. Attention was drawn to the intense inflammatory cell reaction and granulation tissue with exudation on the surface, to the right. This burn will heal but with some scarring.

Another illustration of a somewhat deeper burn on the twenty-sixth day was shown. The burn was below the level of the majority of the hair follicles but the sweat glands had been spared. Regeneration from a deep sweat gland with its tracking to the surface was seen in the middle of the section. This burn would ultimately heal but should really be grafted before it reaches the stage shown.

The sixth illustration showed what happens when a burn similar to the fifth slide is allowed to heal without grafting. This showed regeneration from

\*The author showed a number of slides which have not been reproduced in this issue.

a deep sweat gland but with considerable scarring, and was taken one year after the occurrence of the burn. Regeneration was entirely from sweat glands. There was a thick layer of scar tissue without elastic fibers. This burn should, of course, have been grafted at an earlier period.

The last slide showed what happens when a burn is grafted. This biopsy was taken fifty days after infliction of the burn and fourteen days after the skin grafting shown to the right of the slide was applied. The graft extended one-half way across the field. At the left of the slide was seen a thick layer of granulation tissue with marked inflammatory reaction. The graft extended from the middle of the right of the slide and beneath this, where the granulations were removed before application, was seen an almost complete disappearance of the inflammatory reaction shown in the un-grafted area.

## REMARKS ON VETERANS ADMINISTRATION IN NEW YORK

DR. FREDERIC W. BANCROFT (New York): When I heard Dr. Penberthy speak so well this morning of the organization of the Army Medical Corps, and because the papers have been so full of the maltreatment at the veterans hospitals, I thought it might be worth while to review what is being done at the Bronx General Hospital of the Veterans Administration in New York. Whatever has been accomplished there is largely due, first, to General Bradley's influence and secondly, to the influence and energy of Paul Magnuson.

I have been connected with the Veterans' Hospital in the Bronx for a number of years. It is a 1,900 bed hospital. Before the reorganization of this hospital, there were only two doctors on duty evenings and week ends, and neither of them were surgeons. During this time a large amount of major surgery was being performed and the mortality in severe surgical cases over week ends was sometimes appalling. Now, through the influence of the Deans' Committee, there are senior consultants in each major branch of surgery, and in each major branch there are attending surgeons who are on duty for six months and off duty for six months. These men are all veterans of World War II and are connected with recognized hospitals in New York City.

I shall speak specifically of general surgery. With the help of the Deans' Committee, there are now six attending surgeons in general surgery, three of whom are on duty together for six months. We have not yet arranged for all of the residents to live in, but twenty-five beds have been assigned to them. There are four surgical residents on duty every night and on week ends. The residents are also all veterans of World War II and are all men who are eligible for their Boards.

Under Dr. Whipple's direction, definite courses in training in the basic sciences have been arranged, and the residents have time off to attend these courses. These are given in the various medical schools in New York City. Conferences have been arranged among the residents and such topics as wound healing, routine pre- and postoperative therapy and treatment of infections, etc., are discussed freely.

If nothing interferes, I am confident that in the future, the care of the veterans will be greatly improved. The attendings are all enthusiastic about their jobs and are giving adequate time to the care of the patients and the training of the residents. I happen to be a senior consultant, and while the consultants act in an advisory capacity, as representatives of the Deans' Committee, they have authority.

I wish to state that there has been no political pressure put on us in our appointments of either attendings or residents, and I look forward to a great step in medical education and in the care of patients in veterans hospitals in the future.

# DECONDITIONING OR REHABILITATION— WHICH?

A. WILLIAM REGGIO, M.D.  
BOSTON, MASSACHUSETTS

ON May 30, 1941, at the Annual Meeting of the American Association for the Surgery of Trauma, Dr. Robert H. Kennedy of New York said,<sup>1</sup> "We are wasting a tremendous amount of money and manpower by treating a broken bone and letting a well man get sick physically and mentally while under our care. Then after the damage is done, we spend months, years, or a lifetime trying to bring him back to normal."

In discussing the paper Dr. Frank D. Dickson of Kansas City, Missouri, said,<sup>1</sup> "We . . . have been listening to methods of treatment as far as the fracture itself is concerned and we are learning of more and more methods all the time. There is, however, great danger that we will become so preoccupied with the actual setting of the fracture and its local treatment that we will forget . . . about the human being with whom we are dealing."

It was my privilege to be the second discussor and I said,<sup>1</sup> "One trouble is that many of the doctors who want to get their patients back to work do not know how to get them back. They do not know enough about physical therapy or occupational therapy."

In too many instances all three statements are, unfortunately, still true. How soon will we be able to say that they are no longer true because we realize that our responsibility to the injured patient is not ended until he is back at work?

In the treatment of trauma the emphasis has been mainly on the improvement of technics employed during the acute phase and rightly so but within reason. As physicians it is our duty to bend every effort towards the saving of life and limb of those in our care; but when these two obligations have been carried out there still remains one more, namely, the restoration of function at the earliest moment consistent with good medicine and right here is the big question:

Is it "good medicine" to allow deconditioning to take place in an



otherwise healthy individual and thus delay unnecessarily the return of function and with it lengthen the period of convalescence instead of shortening it?

We all have seen, for example, the "frozen shoulder" resulting from the, let us say, unthinking after-care of a Colles fracture or hand injury. Also the stiff fingers in a similar injury resulting not infrequently from the same type of after-care. Both conditions occur more often than they should. We all realize this but what are we doing about it? The roentgenogram may show an excellent reduction, but that is of very little comfort or use to the patient if the fingers are stiff or the shoulder is frozen and he cannot return to work. Weeks or even months must be spent in physical and occupational therapy trying to regain function which should never have been lost in the first place.

Whose fault is this? We cannot duck the issue, it is our own fault because either we have not realized the extent of our responsibility in treating a case or are not familiar with the rehabilitative measures at our disposal. There is no acceptable or justifiable reason for either excuse.

When an otherwise healthy and physically fit individual is injured he must not be allowed to become "bed happy." Once he does lapse into this state there is nothing but trouble ahead, both for him and the surgeon in charge.

What are a few of these troubles? First of all his muscles rapidly soften up and lose their tone. With this physical deconditioning process he is also very liable to develop other conditions which will tend to impede the recovery and lengthen the period of convalescence.

Deformities may develop due to contractures which could have been prevented by early bedside treatment. Toe drop can be made a rarity. He may be worrying about his job, his family, finances. He just lies in bed deconditioning physically and mentally or if ambulatory, he may be going down hill the same way. He must not be given the opportunity to get into this condition.

We all have seen muscles just melt away and become flabby when this could have been avoided to a considerable degree if the surgeon in charge had made the effort to explain to the patient the importance of exercising the muscles and keeping them exercised. The instructions are simple. Maybe they are so simple that it is beneath the dignity of the "Herr Professor" to demean himself with so elementary a procedure. At least the surgeon can, if he will take the trouble to do so, give orders that the patient be instructed how to

exercise his muscles. At first under supervision until he is proficient in the simple procedure. Then at each visit check progress so that the patient will realize that his doctor is interested in him and has not just delegated someone else to do the supervising.

The patient has confidence in *his* doctor and expects *his* doctor to take care of him because *his* doctor knows best how to get him back to work as soon as possible. But does his doctor merit this confidence? Only too frequently he does not and a disillusioned patient is very apt to progress more slowly as a result.

Let us face the facts honestly and ask ourselves this question: "Are we giving our traumatic patients the best possible care?"

This cannot be answered with an injured air and an annoyed "yes, of course we are" unless it is so.

Let us assume that the acute phase has been handled in the most expert manner and is beyond any criticism. When this hurdle has been passed however and everything is going smoothly, is the surgeon interested in and capable of directing the entire convalescence to the best interests of the patient?

Again, this question may incur the wrath of some surgeons and quite possibly the one who feels seriously insulted by this comment is in the guilty group and naturally resents the implication.

On the other hand many excellent surgeons have never really seen physical and occupational therapy functioning at their best and as a result do not realize how valuable an adjunct these two can be to their efforts in restoring a casualty to economic usefulness. This is not entirely their fault because there have been many erroneous ideas promulgated regarding the work of both physical and occupational therapists.

Physical therapy is not just a lot of baking and slap dash massage or the turning on of various electric gadgets. It is very different from that and an investigation of the methods and modalities employed will prove instructive.

Occupational therapy likewise is not merely the making of belts and leather pocket books. It is a purposeful, functional therapy applied scientifically by trained therapists for the restoration of function.

"The modern therapist is less interested in what the patient does with the material than what the material does with the patient and the articles fabricated in arts and crafts are but by-products on a way station on the road to recovery through the medium of occupational therapy."

The Council on Medical Education and Hospitals of the American Medical Association has set standard requirements for all schools of physical and occupational therapy which must be met before a school can be approved. There are at present twenty-one physical therapy and eighteen occupational therapy schools in the country so approved.

These two professions are closely associated with the surgery of trauma as well as with many other surgical, orthopedic and medical services. When properly used under medical supervision they can by initiating rehabilitative measures at the earliest moment in convalescence (1) avoid serious deconditioning, (2) speed recovery and reduce the period of hospitalization and (3) aid in the earlier restoration of function, thus decreasing residual disability.

The qualified therapists who carry out the work at the prescription of the surgeon are highly trained in their respective professions but can assume the responsibility of treatment only on prescription.

There is another difficulty, namely, the incorrect writing of a prescription for physical or occupational therapy, which however can readily be overcome.

More often than not the physician merely writes: "Referred to P.T." or "Referred to O.T." That is just as sensible and adequate as giving a patient a prescription to the druggist which says, "Give this man some digitalis." It would seem that no further comment is necessary.

To write a prescription for physical or occupational therapy the writer should know what he is writing for. He should give a short, accurate indication of the nature of the injury and what has been done. He should indicate what he wants accomplished by the department referred to. The means or modality of accomplishing this may usually be left to the qualified therapist who is trained in interpreting the prescription, if correctly written, with dates of injury and surgical procedure and any caution to be exercised in giving treatments.

The surgeon should confer periodically with the therapist and review the cases to check progress or regression.

There are a number of physical medicine and rehabilitation departments and clinics doing splendid work. A number of them however receive the patient with the serious handicap of late referral after the date of injury with all its attendant difficulties.

One such clinic<sup>2</sup> reports that of 100 consecutive patients referred for treatment ninety-one had received no physical therapy

before referral, five had some in the doctor's office and four had some in the hospital. The referrals in this same group varied from two weeks to eight months since the date of injury.

Another clinic<sup>3</sup> reports on 100 consecutive patients that the time lapse between the date of injury and referral was from two weeks to eleven months. Fourteen patients were referred within one month after injury, sixty-nine were referred one to four months after injury and seventeen patients were referred from four to eleven months after injury.

The blame for not obtaining a good functional result is then placed on the shoulders of physical and occupational therapy instead of where it belongs, on the doctor. The age of miracles is not yet past but it is a trifle optimistic to expect them to occur frequently enough so as to cover up inexcusable procrastination.

Industry is well aware of the loss in man-hours and wages as well as the high cost of compensation and is doing much to remedy this. More needs to be done and this Association is in an excellent position to help towards that end. Some remedies are suggested:

1. Start in the medical schools by teaching the basic principles of physical medicine, physical and occupational therapy and rehabilitation.
2. Require surgical internes to serve some time in the physical and occupational therapy departments and acquire a working knowledge of modalities and methods used.
3. Require surgical residents to serve some time in these departments receiving all referees and planning the treatment with the chief therapists, as well as administering therapy.
4. Periodically take up rehabilitation matters at staff conferences and have the staff members occasionally visit the departments while in full swing.
5. Have the chief therapists from the physical and occupational therapy departments make periodic ward rounds with the surgeons and attend staff conferences.
6. Allocate time for papers or discussions on rehabilitation at national, state, and local medical society meetings.

Criticism, unless it is constructive, is of little value and is rightfully resented. This address is not meant as a blanket indictment of the physician doing the surgery of trauma as there are many to whom this does not apply. It is however an earnest plea for serious consideration by the members of this Association as to how we can help to remedy a situation which should and can be remedied.

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## DISCUSSION

AUGUSTUS THORNDIKE (Boston): In discussing this interesting paper, one doubts if any one of us here could disagree with any of the basic truths or with any of the means or methods suggested for accomplishing proper rehabilitation of our injured patients. It is true that we all are apt to neglect the whole patient by focusing our attention on the local part. It is true that too much of our interest in these days of hospital bed shortage is concerned with discharging our patients early in convalescence and it is also true that when these patients reach home for convalescence they are largely left to their own devices.

To allay the effects of deconditioning and the abuses of so-called simple bed rest, active physical and mental rehabilitation must commence when the patient is still a bed patient. Most of you are familiar with the studies on negative nitrogen balance, disturbed calcium metabolism and circulatory rates in bed patients by Albright and his co-workers, at Harvard, by Starr and his co-workers at Pennsylvania and by Keys at Minnesota. There is no question but that these disturbances are of vital concern to the seriously injured or debilitated patient. It is my opinion that high protein feeding is not the only means of salvaging a negative nitrogen balance, but that properly directed and executed bed exercises to those uninjured parts of the body is necessary to allay the effects of deconditioning and to correct metabolic disturbances and to improve circulatory rates in our bed patients. Such exercises for those who have seen them are productive of much good. Never shall I forget seeing a dumbbell drill of a whole ward of seriously wounded convalescing leg cases in traction in one of our Army General Hospitals. In such patients there was no opportunity to decondition mind or body.

Physical exercise graduated in intensity as the patient proceeds through convalescence is not the entire answer. Physical therapy and occupational therapy must be coordinated with this. Too many therapists are concerned with the technic of applying heat or massage or with but one item of occupational therapy modality. Due to the limited number of registered occupational therapists it has been difficult to supply the hospitals' needs, at the start of the war there were but 1,500, now approximately 2,500. Occupational therapy has developed and matured during this war, as physical therapy did with the last war. However, unless physical therapists take on more aggressively the remedial exercise aspects of physical medicine, which the army was forced to develop as part of physical reconditioning, much gain will be lost to them. Coordination of these three therapeutic

modalities has been accomplished in army hospitals and should be advanced further in civilian hospitals.

Dr. Reggio brought out the doctors' faults in prescribing exercise or physical therapy or occupational therapy. Many doctors do not know for what they are prescribing, many therapists do not know the patient's basic limitations. The army hospitals found that until the physical reconditioning officer, the physical therapist and the occupational therapist were invited on ward rounds, coordination of all factors involved in convalescent care accomplished little. The doctor cannot merely write a prescription "referred to P.T."

Dr. Reggio called attention to the establishment of new rehabilitation clinics. It has been my privilege to have visited one of these recently and it is a pleasure to report it operating to good advantage for many injured patients. It is my opinion that each civilian hospital or medical center should establish a rehabilitation center for the benefit of those patients requiring prolonged convalescence. This has already been suggested by the Baruch Committee of Physical Medicine. Until such time as these are established convalescent care of traumatic surgical cases will not be optimum. I agree that our medical schools and hospital intern and residency training programs should teach the basic principle and methods used in remedial exercise, physical therapy and occupational therapy. This takes time to establish and involves a new departure from standard hospital procedures, but it is a much needed and worthy undertaking.

I congratulate Dr. Reggio on this excellent presentation of a timely topic.

ALEXANDER P. AITKEN (Boston): I have certainly enjoyed Dr. Reggio's very excellent paper. He has presented a subject which we must all take very seriously to heart and do more than nod our acceptance; we must do something about it.

Four years ago in Boston, it was my privilege to handle a large number of industrial cases and we were thoroughly dissatisfied with the end results we were getting, not only in our own hands but in the hands of other men who were referring cases to us for treatment consequently, we developed what we called a rehabilitation center for compensation cases.

These cases are brought to us from all over New England and eastern New York state. All their expenses are paid. They are provided with hotel accommodations, meals, and transportation to and from home once every two weeks regardless of the distance from which they come.

These patients are sent in for treatment. Our first job, however, is to make a comprehensive diagnosis of what is actually bothering them. We have found that many of them were not making progress because their conditions had not been properly diagnosed. Consequently, many of our cases have been referred back to the surgeon with recommendations as to further treatment before they can be accepted for treatment at our center.

For example, we found in a large group of individuals that they were suffering from reflex vascular spasm. They had cold, clammy feet and conditions which could not possibly be benefited by either physical therapy or occupational therapy. Twenty per cent of our admissions were hand cases, many of them needed further surgery. Many needed skin grafting and the freeing of scars. Many needed tendon transplants.

That is one thing we must be careful of in developing such centers, that we have someone in charge of the center who is capable of making a complete diagnosis and a good, comprehensive survey of the individual, someone who is capable of determining just how much can be salvaged from an individual, the best way to salvage it and the quickest way it can be done.

Patients coming to the center must seek progress, otherwise they will become more discouraged and will be apt to discontinue treatment.

Perhaps the most neglected group of the lot have been the amputees. Certainly the way we civilians handle our amputees is little short of disgraceful. Many of our patients who came in for treatment had amputations performed at a very poor level, the tendency being to make the stumps too long rather than too short. Many of the stumps were painful due to neuroma, but most of the discomfort came from ill-fitting prostheses. Every one of the patients admitted to our center had been equipped with some sort of prosthesis. I can recall no case in which the prosthesis fitted. This was due largely, I think, to the doctor in charge of the case. He made no attempt, simply because he did not know anything about prostheses. Fitting of a prosthesis is an art and something we have all got to learn. We cannot leave it up to the prosthesis maker. They do not know. I am afraid in many instances they do not care much.

Many of our patients were equipped with legs before they got out of bed and before the wounds healed. The idea simply was to sell a prosthesis and such was done and the patient was given the prosthesis and expected that when his wound was healed all he had to do was put it on and get up and walk. No one supervised his stump to see if it was in good condition or not; no one supervised the fitting of the prosthesis or showed him how to use it. That is one thing we have all got to learn. We have got to learn more about prostheses, how they should be fitted and how they are made. We must also learn a good deal more about how to perform suitable amputations for the use of prostheses.

In our center when a patient is admitted, after a comprehensive examination is made of him he is started on physical therapy, given remedial exercises, exercises in physiotherapy and also he is sent on to occupational therapy, where he is given productive work to do. He does not make beaded bags and belts and that sort of thing. We attempt to give him work which as closely as possible simulates his own work.

These people may be rather sullen at first but they soon snap out of it and take a keen interest in their work. It is not at all unusual for a patient to

come up and say, "If I can do the work here, I can do my own work." That is the ideal way to handle them. We may feel that many of these patients are able to go back to work but if they do not agree with us they are not going to return to work. If they can be convinced themselves, that is the ideal way to handle them.

These patients stay all day and work five or five and a half days a week. All the products they make they take home with them.

We feel very strongly the value of such a center, and we know more centers will have to be developed throughout the country. This year, Tufts Medical School is sending to us their junior and senior students to look at the center and see just what can be accomplished.

Answering Dr. Thorndike's remarks, there is a very definite danger in keeping a patient in bed too long. However, in disc cases I think we might gamble on six weeks in bed. When you consider that the end results at the present time, or 45 per cent of the cases, are total losses to themselves and to society, perhaps six weeks is a little long but I think we can take that chance.

This is a subject about which I feel very keenly, and I am very glad Dr. Reggio has brought it out into the open. I hope we as a Society are eventually able to do something concrete about it.



# A METHOD FOR THE ARREST OF SPREADING GAS GANGRENE BY OXYGEN INJECTION

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THE treatment of gas gangrene by injection of oxygen into the tissue, *per se* or through the use of hydrogen peroxide and the direct application of oxygen to the wound, is not new. In fact, the Greeks used the effect of oxygen injection centuries ago. The use of measured amounts under controlled pressure and with aseptic technic, continued over a long period of time, was not possible under past methods.

The machine described later and the method of its use was brought to my attention in June, 1945, when I had a case of gas gangrene of the forearm, secondary to compound fracture of both bones which in spite of gas serum before and after primary operation, secondary operation, amputation, penicillin and sulfa therapy, extended to the thorax. (Only x-ray therapy was not used, although it had been considered.)

By fortunate circumstance, a demonstrator of an oxinjector, who had supervised the injection of oxygen in twelve cases prior to this one, was in the hospital. Not any of these preceding cases involved the trunk. Two patients with a similar condition of the upper extremity were recently seen, one involving the torso, making fifteen cases in all, without mortality and in some instances without loss of limb.

It is understood that the prescribed surgical treatment is to be used on all gas gangrene cases plus penicillin, etc. and that oxygen injection is designed simply for the purpose of walling off the infected areas, preventing further spread and then aiding in the retrogression of the lesions. The addition of it to other treatment has in at least two of the cases been the difference between life and death.

The machine was primarily designed for the treatment of asthma and later for collapse of lung in pulmonary tuberculosis, although it has other uses. It was first used for gas gangrene at the Jewish Hospital in 1937.

The whole compact instrument weighs only twelve pounds. A

new, modified case containing a small oxygen tank is in process of manufacture and will weigh somewhat more. It is easily portable. An oxinjector cylinder is loaded from a medicinal gas tank by the use of a special yoke. These cylinders are similar to the gas capsules with which one charges a seltzer bottle. A loaded cylinder holds 7,000 cc. of oxygen. One can tell when it is fully charged by the fact that it becomes warm in the hand. When the cylinder is turned into the inlet fitting of the apparatus, it opens a check valve in its nozzle. A twist to the right releases gas into the instrument, the amount being indicated on a dial in cc. When full, a left turn shuts the valve and the cylinder is removed.

To the instrument is attached a rubber tube and a  $1\frac{1}{2}$  inch to 2 inches Luer Lock needle, gauge No. 18 to 20, through which oxygen is injected into the tissues. A control knob regulates the pressure of the flow through the needle, registered by a mercury column. Too rapid flow under too high pressure will strip and distort tissue, so pressure is not allowed to exceed 120 mm. of mercury. The optimum operating range is between 100 and 120 mm. of mercury.

Prior to insertion of the needle, the skin to be injected is prepared and injection is begun 1 to  $1\frac{1}{2}$  inches distal to the line of demarcation or advancing edge, i.e., discoloration or crepitation. Punctures are made 1 inch apart and the needle is inserted toward the area of disease and about  $\frac{3}{4}$  of an inch deep. About 1,000 cc. of oxygen are injected at each point subcutaneously and after the complete subcutaneous barrier is thus erected, similar injections are made into the muscle. Owing to the great oxygen starvation of the diseased tissues, it will be necessary to reinject in from one to one and one half hours. Thereafter, injections are repeated every four to five hours to maintain a barrier. After the third injection, it may be necessary only to reinforce the areas where channelization appears likely. Oxygen will be absorbed three or four times more rapidly from the diseased than from the healthy tissue. Injections are continued for twenty-four hours past the time when the disease has apparently been cured, but at 2 inches instead of 1 inch intervals.

It is noted that the temperature drops within one-half hour following erection of the oxygen barrier and is usually normal in twenty-four hours. Beginning with my case and used with the two subsequent cases a hood or tent was set over the open wound or wounds and oxygen was freed at the rate of 10 liters per minute, the wounds being lightly covered with gauze soaked in normal salt solution. Wounds so treated cleared up more rapidly than without

local therapy. Penicillin in large doses was continued through the oxygen treatment period.

There is one precaution to be observed in the upper extremity. If oxygen is inserted in the supraclavicular area it may result in severe earache and in deafness, lasting for six to nine months.

In my personal case the oxygen was inserted through seven portals and eventually oxygen emphysema extended almost to the pubes. Only a small amount of oxygen rose above the clavicle and this produced difficulty in swallowing and talking. In less than seventy-two hours all discoloration had disappeared.

#### CASE REPORT

T. K., white male, aged eleven years, fell from a ladder while picking cherries and was admitted to Delaware County Hospital ten minutes later at 6:30 P.M. on June 1, 1945 with a compound fracture of both bones of the forearm, the ulna with its proximal fragment exposed through a wound 1 inch long. Crepitus and marked deformity were present. The sleeve over the forearm was not torn. A sterile surgical dressing was applied to the wound, the arm was splinted and tetanus and gas bacillus antitoxin (1500 units) given. Roentgenogram showed a fracture of the radius 5 cm. from the distal end with the distal fragment displaced laterally and forward and overlapping of 1.5 cm. The ulna showed a fracture 2 cm. from the distal end and with the distal fragment totally displaced toward the radial and volar aspects.

Within three hours an open operation was performed by my assistant, Dr. Charles A. Steiner, under general anesthesia. Operation consisted of debridement and open reduction through separate incisions without internal fixation. Sulfanilamide, 5 Gm., was sprinkled in the wound which was closed with interrupted silk sutures and without drainage. A posterior plaster splint was applied and a light circular cast over it.

A roentgenogram on June 2, 1945 showed good reduction with satisfactory alignment. The patient's temperature was 100°F., pulse 100, respiration 22, red blood cells 4,050,000, hemoglobin 78 per cent, white blood cells 9,800, neutrophils 86, lymphocytes 12, monocytes 2, stabs 28, segments 58. The urinalysis revealed nothing abnormal. The arm was elevated and the fingers were warm with full mobility. On June 3rd, the temperature was 101°F., pulse 110 and respirations 24; sulfadiazine was begun by mouth. The extremity was apparently normal.

On the following day, the temperature was 102°F., pulse 110 and respirations 28. The fingers were slightly blue and cold but the patient complained of no pain. The cast was removed and the wound showed typical discoloration, crepitation and had the characteristic odor of gas bacillus infection. This was confirmed by laboratory findings of *Clostridium Welchii*,

hemolytic in type. The white blood count was 17,600, neutrophils 79 per cent, stabs 18, segmented 61. Immediate operation was performed with full length incisions. The disease had not spread to the elbow. Gas antitoxin was given in large doses; penicillin, 25,000 units every two hours, was given intramuscularly and 3 Gm. sulfamerazine intravenously.

Within eight hours there was edema above the elbow so a guillotine amputation was performed high on the upper arm without tourniquet (Hinton). Within five hours following amputation the temperature rose to 103°F., the pulse to 160 and the patient became irrational. This was at 9 P. M. when 500 cc. of whole blood was given. At midnight no extension was evident.

Blood cultures taken were negative after seven days. During the morning there was no improvement. The patient was given 3,000 units antigas serum, streptococcic antiserum in large doses, 3 Gm. of sulfamerazine intravenously, 100,000 units of penicillin, continuing 25,000 every two hours and 400 cc. of whole blood. At 2 P.M. the temperature was 103°F., pulse 140, the patient was rational and his skin was cold and clammy. There was now bluish discoloration extending to 4 inches below the axilla on the chest wall but no crepitation. At 3:30 P.M. under aseptic precautions 1,000 cc. of oxygen was injected into each of seven portals according to the method described earlier. This included the subcutaneous tissue and chest muscles but not in the supraclavicular area. There was considerable pain attending the first injections. Wet dressings and a small oxygen tent, begun some hours before, were used over the stump. Five minutes after the injections were completed the patient complained of difficulty in swallowing and talking. At 6 P.M. a second series of oxygen injections was given.

The following is a short summary of the patient's condition from June 6th to July 3rd:

On June 6th, the sulfa level was 25 mg./100 cc. Oxygen injections were given at 6 A.M., noon and 5 P.M. There was marked improvement in the clinical picture. The temperature was 100°F., pulse 110, respirations 32. The patient was rational and the line of demarcation began to fade. A transfusion of 500 cc. was given; the urea nitrogen was 27 mg./100 cc. and the creatine 1.3 mg./100 cc. On the following day more improvement was evident. The temperature had dropped to 99.2°F., and the line of demarcation was retreating. A heat lamp was used at intervals. Oxygen injections were repeated: 450 cc. at 10:40 and 500 cc. at 12:50. A transfusion of 500 cc. of blood was given and the sulfa level dropped to 6.3 mg./100 cc.

On June 8th, oxygen to the stump and wet dressings were discontinued. Oxygen injections were continued at intervals and the line of demarcation and discoloration disappeared. One Gm. of sulfamerazine every six hours was continued for four more doses. The red blood count was 4,300,000, hemoglobin 82 per cent, white blood count 10,000, neutrophils 76, stabs 21, segments 55, urea nitrogen 19 mg./100 cc. On the following day tem-

perature, pulse and respirations were normal, and penicillin 12,500 units was administered every four hours.

On June 11th, some subcutaneous emphysema of oxygen persisted over the chest and abdomen. The sulfa level was 2 mg./100 cc. and 6,300 units of penicillin was given every four hours. On June 12th, a culture taken from the stump was negative for *Bacillus Welchii*. Potassium permanganate soaks 1:2,000 were applied every three hours. On the following day the penicillin was stopped.

On June 19th, a moderate secondary anemia was present; the red blood count was 3,600,000 and hemoglobin 84 per cent. On June 22nd, after preliminary wound cultures, tetanus antitoxin and gas bacillus antitoxin, the stump was revised under anesthesia (Steiner). On that day a 500 cc. transfusion was given, and on the following two days transfusions of 300 cc. and 200 cc. were administered. On June 26th, the hemoglobin was 98 per cent and the red blood count 5,030,000. The patient was discharged from the hospital on July 3rd and later was fitted with an artificial arm.

#### SUMMARY

This paper is given to present a controlled and scientific method of blocking the spread of gas bacillus infection of extremities and trunk, and as an adjuvant to proper surgery in gas gangrene. It requires no special skill to administer and may be done by anyone under medical supervision.

I wish to give full credit to Dr. Harold H. Engle, Surgical Resident, who from the very beginning urged oxygen therapy and who spent many sleepless hours giving the oxygen injections.

# SURGICAL WOUNDS OF THE ABDOMINAL WALL WITH THEIR FAVORABLE AND UNFAVORABLE RESULTS

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NOT all abdominal wounds are the result of accidental trauma. Incisions made by the surgeon in abdominal operations may be of two varieties and classed as wounds or incisions. When the abdominal wall is traumatized unnecessarily by an ill-advised incision it should be called an abdominal wound. On the other hand if anatomical structures are respected the incision may produce little disturbance and then only should be designated as an abdominal *incision*.

Those of us who have been associated with medical education for a long span of years have seen anatomy, once the most important major subject in the medical curriculum, now assigned to a minor rôle and we feel that if there ever was a time for surgical anatomy to be emphasized it is the present time.

The age old incisions are so firmly fixed in the habits of surgeons that it is difficult to dislodge them. The average surgeon is so intent upon getting to the pathology in question, the stomach, the gallbladder, the diaphragm or the colon, that he resents the delay which might be caused by comprehensive knowledge of the abdominal wall, though he will spend many hours in preparing himself with the study of the minutest detail of the technical removal of the organ in question.

This discussion will be directed particularly to: (1) Those surgeons who have at one time or another had difficulty in getting a good exposure of the field of operation in certain abdominal procedures; (2) those who occasionally have wound disruption occurring postoperatively; (3) Those surgeons who have had his or other surgeons' patients come to him with postoperative hernia; (4) those surgeons whose patients have painful postoperative convalescence or too frequent pulmonary complications, and (5) those surgeons, who have a fear of wound failure and use some special means of preventing it, such as special suture material of silk, cotton or wire, chromic catgut; or special types of sutures, such as figure-of-eight,

deep stitches or special supports of the abdominal wall postoperatively to protect their wounds.

*Vertical Incision.* The long vertical incisions (mid-line, right rectus, left rectus) were at one time probably justified when intra-abdominal diagnosis was less precise but with modern diagnostic skill and diagnostic agents, exploratory operations are infrequent. The older surgeons frequently feel it necessary to extend their incisions upwards or downwards, depending upon the direction the pathology was found after exploration. Too often it is not realized that the making of a second incision is always safer for the patient than stretching or enlarging the original incision unnecessarily long.

*Faulty Wound Healing.* The contributing factor to faulty wound healing in the abdomen are many but in our opinion a proper regard for anatomical incisions makes the other causes assume a place of small importance. It is true that vertical incisions may result in a strong union if everything goes well but one cannot anticipate in every instance when a patient will develop an ileus with gaseous distention or a troublesome cough, postoperative vomiting or slight infection in the wound. Should one or more of these complications arise the vertical or unanatomical incision will give way invariably while the patient with the anatomical incision will survive such complications without separation of its edges and faulty union.

It is evident from the study of the literature that unsatisfactory restoration of the abdominal wall is quite common and our own experience has been very convincing. Some years ago we made a study of 9,000 consecutive abdominal incisions in the John Sealy Hospital and this furnished us definite proof of the above statements. In this review there were 5,853 incisions that had been classed as nonanatomical. These were vertical incisions (mid-line, upper rectus and lower rectus). Of this number there were sixty disruptions with a high mortality in these sixty patients, and there were to our knowledge from 2 to 3 per cent postoperative hernias. Unquestionably there were a great many more that we were not able to follow who developed ventral hernias. Some fifteen years ago we abandoned the vertical incision in the upper abdomen and in many instances in the lower abdomen. The result has been the almost complete elimination of disruptions and postoperative hernia being extremely rare and found only in a few cases where drainage of the abdominal cavity was necessary. This investigation in itself would indicate that we were justified in claiming that the anatomical incisions are not only worth while but obligatory upon the surgeon, and that the older vertical incisions should be dispensed with.

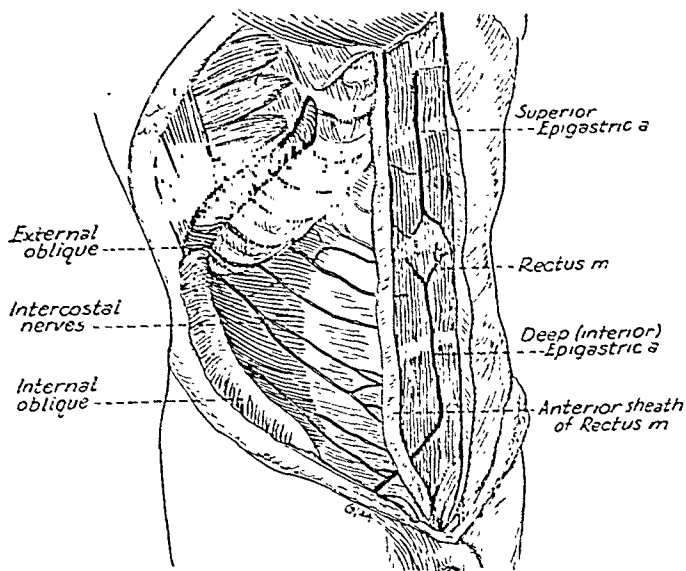


FIG. 1. Standard anatomical drawing showing blood supply, nerve supply and muscles of the abdominal wall.

*Anatomy.* The important anatomical structures in the abdominal wall, are of course *blood vessels, nerves, muscles, fascia and skin.* (Fig. 1.)

Fortunately the abdominal wall is richly supplied with *blood* from many sources and one is rarely afraid of devitalizing tissues to the extent of interfering with this blood supply which might interfere with healing, though the incision may be anywhere in the abdomen. The intercostals, superior and inferior epigastrics with their many anastomoses, supply the abdominal wall freely with blood.

The *nerve* supply, both sensory and motor, is abundant. Because of the many intercostal nerves and their intercommunications, it is difficult to denervate any part of the abdominal wall, though numerous nerve trunks may be severed. We have frequently tested patients who have had lateral transverse incisions with the severing of as many as three intercostal nerves, to find that in two or three months time there is complete restoration of sensation and muscular power to the skin and muscles directly supplied by these nerves.

The *muscles of the abdominal wall* and their function are well known to the surgeon. The recti muscles run parallel with the long way of the body and these muscles are largely used to splint the abdomen and protect the intra-abdominal structures from traumatism. The other general muscles, commonly called the flat muscles, are the external oblique, internal oblique and transversus.



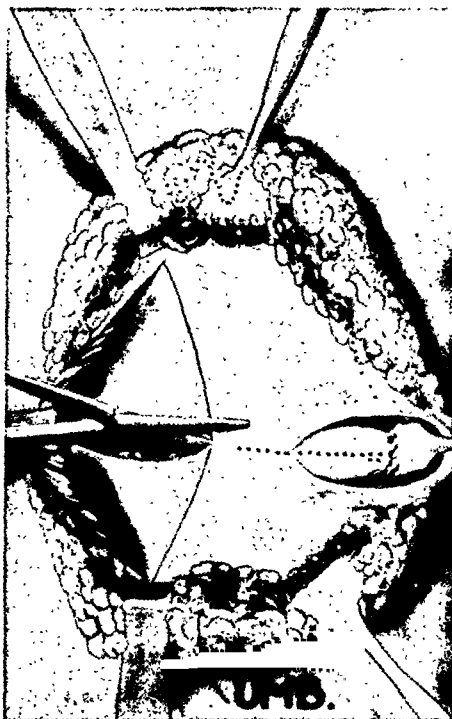


FIG. 2. Sloan incision. Skin incision made vertically or transversely. Retraction of skin is exaggerated to show the fascia in this area.



FIG. 3. Sloan incision may be enlarged by retracting the rectus muscle on the left as well as on the right side for resection of the stomach.

These muscles have a function which is much more complicated than the recti; they not only maintain the positive pressure in the abdomen, almost entirely encircling the body, but at the same time they are respiratory muscles and are never at rest. During extra effort, such as retching or vomiting, sneezing or coughing, the pull upon these flat muscles across the abdomen is very great. The fibers of these muscles run generally in a transverse direction; therefore, in order to maintain a satisfactory abdominal wall, incisions through them should be in a transverse direction.

*Fascia of the abdominal wall* is its most important holding structure and where the tension is greatest the fascia is more abundant. The fascia of the abdominal wall must be thought of as the tendinous continuation of the muscles. The flat muscles arise from the ribs, lumbar fascia and ileum and their tendinous insertion is in the mid-line of the abdomen. These tendons form the anterior and posterior sheaths of the recti muscles. The fibers of these tendons run in a transverse direction, meeting in the mid-line and form the linea alba. If one cuts the fascia vertically it is across the direction of its fibers

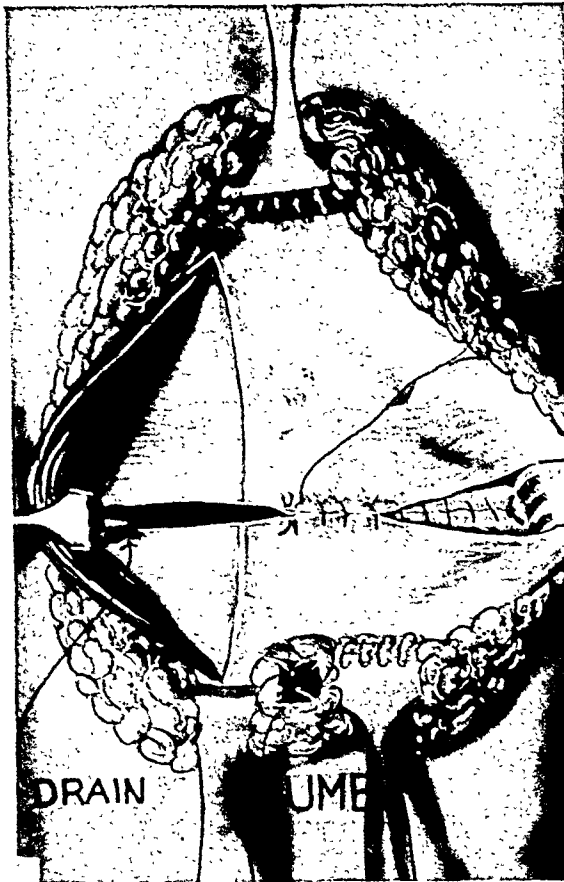


FIG. 4. Fascia comes together without tension guaranteeing security and healing.

and the direction of muscle pull and it requires a tremendous amount of effort to maintain it in position during sneezing, coughing or vomiting or when there is great gaseous distention, these flat muscles will invariably pull the ends of fascia approximation apart. The average surgeon would hesitate very much to cut the tendon of the muscles of the forearm or of the leg knowing the great difficulty of suturing them together and maintaining the position. On the other hand, he does not hesitate in the vertical incision to cut the tendons of the muscles across the direction of their pull.

*Suture Material.* We might say here that we believe the controversy over suture material is largely due to the fact that surgeons endeavor by the aid of suture material to overcome the tremendous pull necessary to maintain this fascia together and that the controversy over the use of various types of suture material will continue without a decision so long as surgeons disregard the anatomical arrangement of these structures and endeavor to restore and maintain the tissues of the abdominal wall together after unanatomical

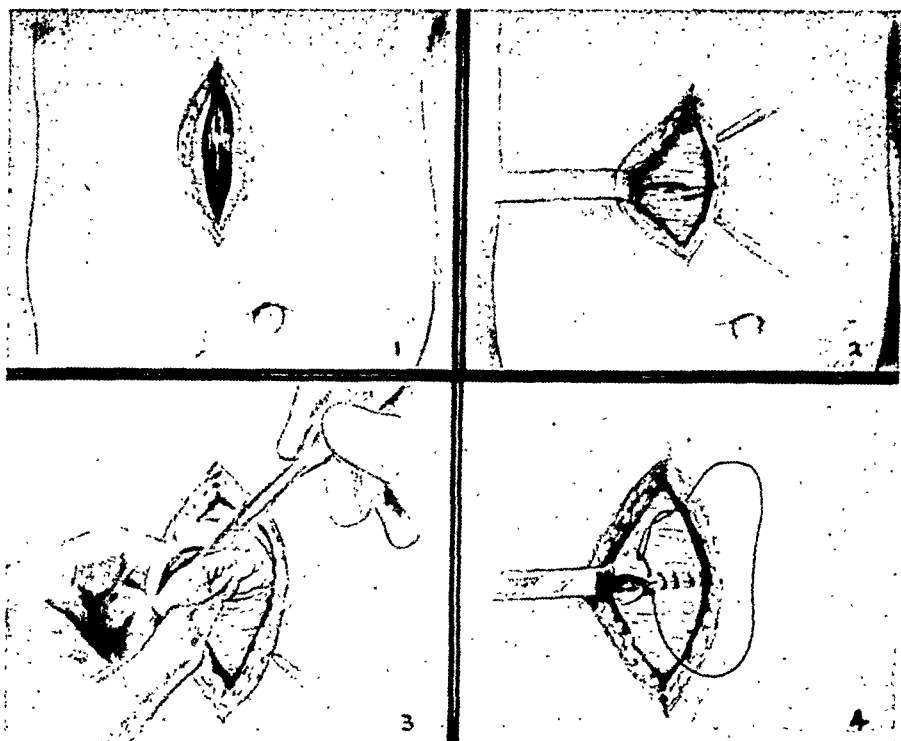


FIG. 5. Muscle and fascia-splitting incision in the upper abdomen for pyloric stenosis and gastrostomy.

incisions. There is hardly a place in the abdomen where one cannot secure adequate exposure for surgical operations and still make the incision between the muscle fibers or fascia fibers parallel with the line of tension and thus avoid the difficult problem of keeping the wound edges together. If the tension upon the wound is great enough to require strong sutures the result will always be strangulation of the wound edges and the union will be impaired. On the other hand, if the incision is made in such a way that the edges will be approximated without tension, the tendency to disrupt is not present and good circulation will prevail with sound healing assured.

*Upper abdominal vertical incisions* give the greatest difficulty. It is here particularly that the transverse incision gives the greatest satisfaction. A few surgeons have been interested in the incision problem for many years. Anatomical incisions, particularly those of transverse nature, of various type have been advocated by Pfannenstiel, Boeckmann, Moschowitz, Quain, Bartlett, Sloan and others. Moschowitz, Coller, Gurd and others have advised transverse incisions as a general principle in the abdomen, particularly the upper abdomen. Some of these have disregarded ana-



FIG. 6.



FIG. 7.

FIG. 6. Lateral transverse incision. Skin incision made parallel to the costal border. The anterior sheath of the rectus and the external oblique tendons and muscle cut across. The posterior sheath is incised transversely and the incision carried between the fibers of the internal oblique, across the transversus and peritoneum in line with the skin incision, the rectus muscles being retracted medially and preserved.

FIG. 7. This incision allows the exposure of the gallbladder and biliary ducts so that accidents to these ducts should not occur in this operation.

tomical structures to the extent that the rectus muscles are cut across. The writer has frequently called attention to the fact that the rectus may usually be preserved and serve a useful purpose if retracted out of the way and replaced subsequently. In all of these, maintaining apposition of the wound edges requires much less effort than vertical incisions and gives much greater assurance of a sound abdominal wall postoperatively. There is hardly any excuse for a surgeon not to have a good working knowledge of the anatomy of the abdominal wall. With a working knowledge of the abdominal wall the surgeon may open the abdomen at any location with a safe muscle and fascial splitting incision, securing good exposure and a safe restoration of the tissue involved.

Though the vertical incision is commonly used, it does not give the surgeon access to the organ which he is trying to reach. Vertical incisions for operating upon the gallbladder, right and left colon, spleen and appendix, are far distant from the organs attacked, making the operation much more difficult than if the incision were made in the region of the pathology.

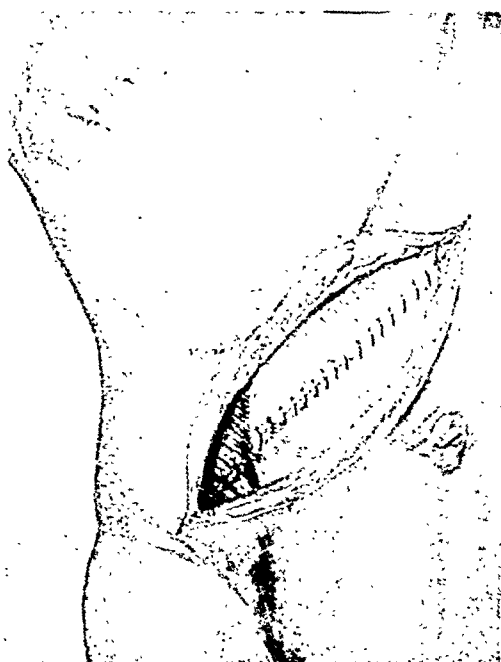


FIG. 8. Abdominal wall is closed in two layers. The posterior sheath, internal oblique and transversus in one layer, the anterior sheath, external oblique in another layer, giving a strong abdominal wound.

*McBurney Incision.* The first one of the muscle fascia splitting incisions to become popular, was of course, the McBurney incision, which at the present time is acknowledged to be the most preferable incision for operation upon the appendix. Some object to the McBurney incision claiming they do not secure sufficient room, but one should know that the McBurney incision may be modified or extended without weakening the abdominal wall. It may be enlarged downwards by incising the rectus sheath beneath the external oblique fascia, securing room to reach the pelvis for operation upon the uterus or adnexa, or may be extended upwards with removal of the right half of the colon which we have done on many occasions. The McBurney incision should be made at a higher level than was originally planned because of the frequency of a high cecum. It is difficult to bring the cecum down when it is attached high; on the other hand, it is very easy to bring the cecum up should it extend over the pelvic brim. (Figs. 2, 3 and 4.)

The *Sloan incision* for the upper abdomen is the most perfect of all anatomical incisions from the standpoint of anatomy, and a working knowledge of it should be had by every surgeon. If one



FIG. 9. This incision on the left side is made in the same way. It is particularly useful in splenectomies and in operations upon the diaphragm.

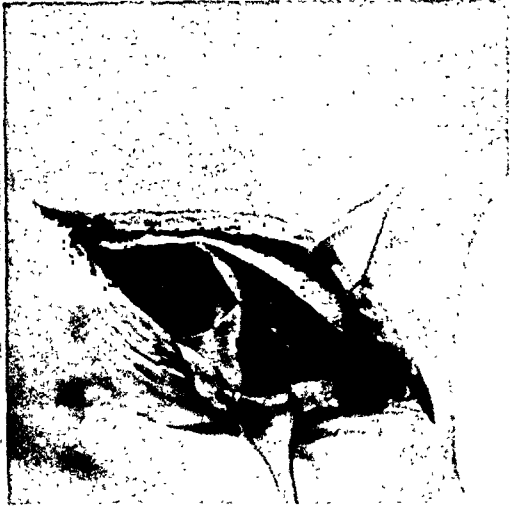


FIG. 10. Anterior sheath of the rectus and external oblique fascia incised. Anterior sheath of rectus muscle liberated from muscle.

practices the Sloan incision a few times he will certainly become familiar with the anatomical structures of the abdominal wall from an incision viewpoint. The skin incision is made vertically or transversely, the anterior rectus sheath is incised vertically on the right side, and the median portion of the anterior sheath dissected off the muscle carefully to the mid-line, and the muscle retracted laterally. This does not disturb the circulation of the muscle or its nerve supply. This freeing of the rectus muscles should be from very high up down to below the umbilicus. An incision is then made transversely through the posterior sheath to the linea alba. This gives sufficient room for exploration and for care of perforated ulcer or doing a gastroenterostomy. If a subtotal or complete resection of the stomach seems necessary, the anterior sheath of the opposite rectus may be incised vertically, and the muscle pulled laterally as on the right side. The transverse incision through the posterior sheath is extended across the linea alba and all the way to the rib margin on the opposite side. This gives an abundance of room for a resection of the stomach in its entirety or any part of it. Gallbladder surgery may also be done through this incision.

In the closure of the wound the extra time spent in making the incision is compensated for by the very easy and rapid closure. The posterior sheath of the rectus is the chief holding material in this part of the abdomen. The pull upon it is in a transverse direction and it is brought together and maintained without tension. If the



FIG. 11.



FIG. 12.

FIGS. 11 and 12. Through this incision the gastrosplenic ligament is doubly ligated and divided up to the diaphragm. The splenic artery is identified and ligated along the upper border of the pancreas controlling the circulation before the spleen is delivered.

patient strains or retches the more securely the posterior sheath is brought together.

For the past nineteen years we have used this incision exclusively for operations upon the stomach. We have yet to see a wound disrupt and have seen only one small epigastric hernia.

We should keep in mind that in *pyloric stenosis* in infants, muscle and fascia splitting (Fig. 5) incisions to the right of the mid-line makes a wound that is sufficiently large to deliver the tumor and incise it without the danger of the intestines being forced out. Also *gastrostomy* to the left of the mid-line with the same type of incision is much more desirable than the incision which cuts the posterior sheath of the rectus in a vertical direction.

A *lateral transverse incision* upon the gallbladder and biliary passages on the right side and the spleen and splenic flexure of the colon on the left side, has given us satisfaction for a number of years. (Fig. 6 and 7.) These incisions are made through the skin parallel to the costal border and an inch or two below extending from the midline to just above and posterior to the anterior superior spine. In line with the skin incision, the anterior sheath of the rectus muscle, which is a continuation of the external oblique fascia, is cut across and the external oblique fascia is cut across with a continuation of the incision far to the right or to the left, if on the left side. In line with the skin incision beneath the external oblique will be found

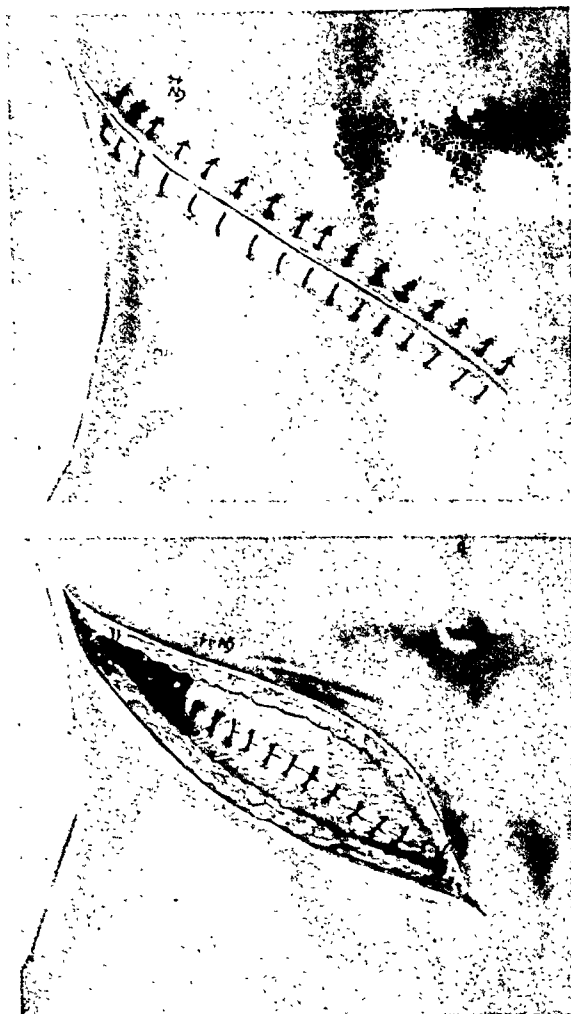


FIG. 13.

in line with the internal oblique fibers which are the strongest of the flat muscles. The anterior sheath of the rectus muscle is dissected free of the rectus for an inch or two above and below where it crosses the muscle, and the rectus muscle is retracted medially. This exposes the posterior sheath, which is cut beneath the rectus muscle, extending from the mid-line and continuing on between the fibers of the internal oblique and through the transversus muscle and peritoneum to the extent of the incision laterally.

This incision gives an exposure to the biliary ducts and gall-bladder that no other incision will equal. Most of the accidents which occur to the ducts during biliary surgery are largely due to the fact that the surgeon does not have satisfactory exposure of the cystic duct, common bile duct and cystic artery.



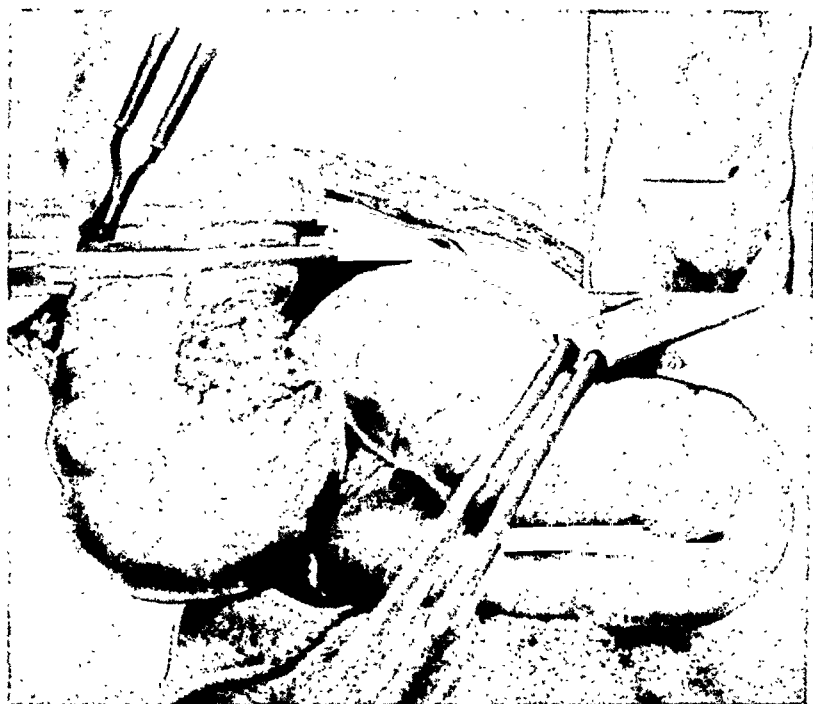


FIG. 14. Transverse incision on either side of the abdomen for colon surgery may be used and the rectus muscle preserved by dissecting the anterior sheath from the muscle and retracting it toward the mid-line.

The wound is closed in two layers; the peritoneum, transversus and internal oblique with their tendons in one layer and the anterior sheath of the rectus with its muscle, the external oblique, is brought together with another suture. This incision may be made a little lower and used very well for resection of the cecum or right colon. (Fig. 8.)

On the left side this incision is just as useful for removal of the spleen, for resecting the splenic flexure of the colon, and operations upon the diaphragm. This incision has many advantages for the removal of a large spleen. It is possible to get excellent exposure, ligate the splenic artery, the gastrosplenic omentum up to the diaphragm before delivering the spleen. After the spleen is removed, one has excellent access to the diaphragm and bleeding from the splenic bed may be controlled under direct vision. (Figs. 9, 10, 11, 12 and 13.)

As previously stated, some of our ablest surgeons have recommended transverse incisions on either side and even across the mid-line for operations upon the colon, cutting across the rectus muscle and linea alba at various levels from the costa border down to and

below the umbilicus.<sup>7</sup> These incisions are very satisfactory and far superior to the commonly used vertical incision from the standpoint of exposure of the field of operation and from the postoperative comfort of the patient and safety of the abdominal wall. (Fig. 14.) On the other hand we find that the rectus muscle can be retracted out of the way with a little more effort and it serves a useful purpose by giving added strength and safety to the abdominal wall postoperatively.

In *accidental or true traumatic wounds*, such as gunshot wounds, stab and incised wounds which are encountered in civil as well as military practice, this same principle of the proper regard for the anatomy of the abdominal wall should be used. Proper regard for infection by debridement and then enlarging the wound by separating muscles in the line of their cleavage and incising fascia in the direction of its fibers, will allow one to do the intra-abdominal surgery necessary and restore the wall in a manner that will give the greatest comfort and safety to the convalescence of the patient.

#### SUMMARY

Surgical incisions in the abdomen made without regard for the anatomical structure involved may be truly traumatic wounds. The old well-established vertical incisions, particularly in the upper abdomen are unanatomical, difficult of closure and hazardous to the patient. Incisions made with the proper regard for the cleavage of the tissues of the abdominal wall, both muscles and fascia, contribute to the comfort and safety of the patient. Such anatomical incisions can be made in proximity to the pathology involved insuring greater ease and accuracy in the operation, in addition to leaving wounds that are closed without tension and with a greater security to the patient postoperatively.

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## DISCUSSION

LAURIE H. MCKIM (Montreal): I wish first to thank Dr. Singleton for the privilege of discussing this very valuable paper.

The transverse incision has been used by Dr. Gurd and myself for approximately twenty-five years, and it has been used as a routine procedure. I would agree first with all of the advantages that Dr. Singleton has pointed out.

The incision which Dr. Gurd and I use is not quite the same as the lateral one which Dr. Singleton has described. We prefer to use a directly transverse incision, that is, the incision is directly across the abdomen at right angles to the mid-line. We find that by the use of this incision we can do about 60 per cent of our gallbladder cases without division of the rectus muscle, but we do not hesitate to divide one of the rectus muscles or in fact both of them should the need be apparent. We consider it is much better to enlarge the incision to any required length than to traumatize the tissues by the use of unnecessary traction or pressure of the tractors upon the muscles of the abdominal wall.

There are certain tricks that we believe are worth while. The first of these is that the incision should not be made too high in the upper abdomen nor too low in the lower abdomen. It should be made fairly near the umbilicus, usually about one inch above or below. When this point is taken the incision may be prolonged, if necessary, to within about four inches of the mid-line behind. You can open them from one side to the other. You rarely damage any nerve supply and the incision is easily closed.

There are certain items of technic that we believe are important about the closure. The most important of these is to accurately close the anterior sheath of the rectus if the rectus has been divided. You should not allow any herniation of the muscle between the cut edges of the fascia of the rectus sheath.

There is one further point: special attention should be paid to the closure of the posterior sheath in the mid-line. The few cases of eventration that we have ever seen have occurred in this region and have occurred following operations in the hands of men who did not understand the importance of accurate closure in the mid-line, where a little bit stronger closure is required than elsewhere.

Dr. Singleton has referred to the fact that these patients have a smoother convalescence. We feel sure that is the case and we believe that the directly transverse incision which we use has slight advantage over Dr. Singleton's incision in one respect; that is, by the use of the transverse incision at right angles to the mid-line you usually stimulate only one spinal segment. We believe this is important. If you will observe these cases and particularly gallbladders done by this method, the amount of postoperative pain and discomfort, distention and all the other complica-

tions, is immeasurably less than you get in the long vertical incision where undoubtedly you stimulate three and possibly four spinal segments.

PRESIDENT PENBERTHY: Thank you, Dr. McKim. Owing to the lateness of the hour I am going to ask Dr. Singleton to close the discussion.

A. O. SINGLETON (closing): I have nothing further to say except that a good deal of physical therapy was discussed earlier, to the ambulatory patient's advantage. I have always believed that the patient with an abdominal operation should not necessarily be tied in bed. I think the use of an ordinary bed pan with the patient lying in bed is the greatest strain upon the abdominal wall we could have, even though he gets out of bed and scrubs the floor.

Patients with a high incision, in whom important structures are not cut across, do have an easier convalescence, and you certainly are perfectly safe in getting them out of bed.

# TENOSYNOVITIS OF THE FOREARM

ROBERT L. RHODES

AUGUSTA, GEORGIA

**T**HIS lesion, frequently looked upon lightly and treated carelessly, may prove of serious consequence or even become calamitous in some cases. In my experience it is rather peculiar to certain classes of workers particularly those requiring powerful grip action of the hand and those whose hands are constantly subjected to vibration or oft repeated jolts. It is by no means uncommon in such workman.

It occurs usually in the region of the wrist, more frequently the dorsum and involves the extensor tendons, particularly of the thumb, occasionally occurs upon the palmer aspect and involves the flexor tendons. Not infrequently it is higher up on the forearm about midway the dorsal surface where it is much more apt to be caused by direct blow such as being struck across the forearm by a falling brick or piece of lumber. Automobile mechanics, so many of whom use pliers almost exclusively instead of a wrench, are rather susceptible; workers around brick kilns, particularly those who catch brick pitched from ten to twelve feet above. Here we have not only strong grip action but the jolt of stopping the brick, workers around saw mills and lumber yards who also use strong grip action and are subject to jolts and vibrations of the hands throughout the day's work. I have never seen but one case in the left arm and that was a railroad engineer in whom the left is the throttle arm and therefore in much more constant use. Incidentally he was quite obstinate, refused to heed advice or appropriate treatment, developed tuberculosis of many of the extensor tendons and ultimately his arm was amputated. At the onset, I am sure, he had only a simple lesion and subsequently tuberculosis became superimposed.

Simple tenosynovitis is characterized by severe pain sharply localized upon motion of the involved tendons, quite tender upon palpation and coarse crepitation. There is but very little if any swelling. Tuberculous lesions have very little pain or tenderness, swelling is fusiform in type of the involved tendons, nodular and crepitus is of a much softer type. As the disease progresses swelling may become egg shape and rice bodies may become palpable. I have never seen a case of the tuberculous type who did not give a very

definite history of one or more attacks of simple nature or trauma and I am convinced that tuberculosis is not primary but becomes superimposed in an area of lowered resistance. To prevent this development by stressing this thought, is the chief reason for this discussion.

Treatment of the simple lesion consists in complete immobilization to secure absolute rest of the tendons involved. I do not fear adhesions, as we have been admonished, but maintain the above until at least one week after all pain, tenderness and crepitation have disappeared. Light work for two or three weeks after which regular work may be resumed if there has been no flare up. I have had several cases whose work has had to be changed because of repeated recurrences.

Tuberculous tenosynovitis should be promptly operated as soon as the diagnosis is made. The keynote is most meticulous sharp dissection of all tubercles and areas of inflammation on both tendons and sheaths, not overlooking the under surface of the tendons. If done thoroughly the disease will be eradicated, on the other hand if one little granuloma is left, it will recur. Immobilization for two or three weeks followed by motion, very slight at first but gradually increased until full function is restored. These cases will develop adhesions with limitation of function if kept immobilized too long. Whether beneficial or not, I do not know, but I have had them expose the wrist or arm to direct sunlight for half an hour or more daily for months following. So far I have had no recurrences. Of course the primary focus of the tuberculosis infection should be diligently sought but this is most discouraging and disheartening because, in my experience, it has been totally fruitless. In no case have we been able to locate the primary lesion until months or years later when it became manifest, as I will illustrate in the report of several cases.

#### CASE REPORTS

CASE 1. The patient was a robust young negro man, twenty-three years of age, who was an ice cream delivery man in the days when ice cream was delivered in 10 gallon churns, packed in ice in large wooden containers. Strong grip action was required in handling these heavy containers. He developed tenosynovitis of the extensor tendons of the thumb for which the hand and arm were completely immobilized for thirty days until completely recovered. He was then returned to work but cautioned to only drive the truck and let another man do the delivering. After several months he began to handle the containers again and developed a recurrence. Again

it was cleared up by rest and immobilization and he was returned to work with the same admonitions. In about six months he returned this time with a fusiform swelling crepitus and low grade fever. This was felt to be tuberculous, was operated under intravenous procain anesthesia, rice bodies evacuated and all inflammatory tissue sharply dissected from the tendons and sheaths. Recovery was prompt and uneventful. Careful examinations, including sputum and x-rays of chest failed to reveal any evidence of the primary focus. He worked five months as a truck driver when he went to New York, obtained a position of a Pullman porter and worked at this for two and one-half years when he was laid off because of his health. He returned home, both lungs were riddled with tuberculosis and he died a month later. He did not have any recurrence of the tenosynovitis.

CASE II. The patient, a white man whose occupation was a telephone lineman and who used pliers almost exclusively. He had a simple tenosynovitis with tenderness and crepitus of the extensor tendons of the thumb which was cleared up by immobilization and rest. He, too, had a recurrence after several months which again cleared up under treatment. A year and a half later he developed a recurrence with nodular fusiform swelling, crepitus, rice bodies and so on. This was operated and he made an uneventful recovery. Careful search failed to reveal any primary focus. Two years later his health began to decline and he was given light work in the stock room for two years when he developed urinary symptoms. Check at this time showed bilateral tuberculous kidneys and bladder and he was put to bed and efforts made to build up his strength. However, he steadily declined, soon showed a tuberculous peritonitis and enteritis and died in a few weeks.

CASE III. A forty three year old general merchant in a small town, who cut his right wrist on a broken bottle over the lower end of the ulnar, palmar aspect. He went to the doctor who cleaned it out and sutured the wound. It apparently healed satisfactorily. A month later while fishing, his foot slipped and he fell, breaking the fall with his right hand. The site of the recent laceration promptly began to pain and swell into a lump about 1 inch diameter and elevated about half an inch. After a few days it broke open and discharged a serous fluid. All treatment failed and after a month he came to see me at which time the size of the lesion was as above and presented a dirty granulosomatous appearance. Thinking that probably a piece of glass was in the wound, I advised exploration and excision of the area. This was done and quite to my surprise we found a tuberculous tenosynovitis of the flexor carpi ulnaris, all inflammatory material was carefully excised shaving it from the tendons as well as the sheath, the wound was closed and immobilization splint for two months, then gradually function was restored. Here again thorough checking failed to reveal the primary focus. The wrist remains well and his general health seems to be good after a year but I anticipate that some day his focus will declare itself.

Thus tenosynovitis deserves a little more consideration or respect than that ordinarily accorded it. Repeated or recurring attacks are quite significant and demand a change of occupation or type of work because of the very definite predisposition for tuberculosis to become engrafted upon it. Should this occur immediate excision of all infected tissue is indicated to prevent extension to other tendons which may lead to the loss of the arm or even life.

#### DISCUSSION

GEORGE HORTON (San Antonio): I think Dr. Rhodes is to be congratulated upon bringing us such an important subject.

I should like to add one condition of which I have seen a lot and that is the specialized form of stenosing tenosynovitis of the abductor pollicis longus and extensor pollicis brevis, (De Quervain's disease), which occurs quite frequently in women. It is localized pain over the dorsum of the wrist, in the region of the dorsal carpal ligament. Conservative therapy very seldom, in my experience, has yielded any satisfactory results. However, it is a very simple matter to excise the small part of the stenosing ligament and the results are practically uniformly favorable.

I do not recall having seen much of the condition in men but I have seen a lot of it in women and I think perhaps the use of the iron without a thumb-rest is one of the common causes. It is a common condition and can be so easily relieved with a local anesthetic that we should not overlook this condition.

CASPER F. HEGNER (Denver): I cannot give any authority for this simple type of tenosynovitis but it was originally described in shinglers who used a hammer that jolted the wrist. It recurs frequently. It is strange that in Denver and Colorado, where we have so many tuberculous cases, that tuberculous synovitis is not as common as this paper would lead us to believe and when it does occur it is a tremendously difficult thing to control.



## SCALENUS ANTICUS SYNDROME\*

MIMS GAGE, M.D. AND HOMER PARNELL, M.D.

NEW ORLEANS, LOUISIANA

THE scalenus anticus syndrome is a definite clinical entity characterized by a train of symptoms resulting in a nonfatal disability of the upper extremities. These symptoms are the result of pressure upon the component parts of the brachial plexus and the subclavian artery by the scalenus anticus, scalenus minimus and scalenus medius muscles and the first rib. The condition can be recognized by the clinical manifestations of pain, numbness, tingling, sensory changes and muscular weakness amounting sometimes to complete paralysis of the extensor muscles of the wrist and fingers. These neurogenic signs and symptoms may be associated with muscle spasm in the arm, forearm, shoulder and neck as well as with various vascular changes of the arterial supply to the upper extremity. Vasomotor phenomena may or may not be primary or secondary to these vascular changes.

In 1934, Ochsner, Gage and DeBakey<sup>23</sup> described this syndrome and reported six cases in five of which operation completely relieved the symptoms. The various prevailing theories were discussed and we advanced the hypothesis that the symptoms are produced by spasm of the scalenus muscle with secondary hypertrophy which presses the brachial plexus and subclavian artery against the scalenus medius and first rib; the first rib, in turn, is elevated by the muscle spasm and this increases the irritation or pressure on the lower trunk of the brachial plexus, thus causing a vicious circle. The etiologic factors responsible for the spasm of the scalenus muscle could not be adequately explained except by the theories of Todd<sup>30</sup> and Jones.<sup>14</sup> Todd believed that the failure of descent of the sternum with the shoulder descent resulted in high fixation of the first rib, producing brachial plexus irritation, whereas Jones felt that the dorsal nerves joining the lower cord of the brachial plexus were compressed by the first rib. In accepting these two theories, we stated that irritation of the brachial plexus resulted in spasm of the scalenus

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anticus muscle with its train of symptoms. At that time we found definite histologic evidence of inflammation and degeneration in the removed portions of the scalenus muscles. Since then, many articles<sup>2,5,9,13,15,21,23,25,30,31,32</sup> have been written on the scalenus anticus syndrome but an adequate explanation as to the etiologic factors responsible for the spasm of the scalenus anticus muscle and irritation of the brachial plexus has yet to be offered. That spasm of the scalenus anticus muscle is definitely present was adequately demonstrated by me in 1939 by injection of the scalenus anticus with procaine hydrochloride;<sup>8</sup> anesthetization of the muscle caused relaxation of the spasm with complete relief of symptoms.

Aynesworth<sup>1</sup> in 1940, agreed that spasm of the scalenus anticus muscle probably causes the symptoms by pressure upon the brachial plexus and suggested that myositis of the muscle is the motivating factor in the production of spasm. Nachlas,<sup>22</sup> differing from most authors, believed that many factors were involved. However, he thought that the symptoms were due to nerve irritation from arthritis of the cervical spine with narrowing of the foramina. He suggested the term "brachialgia," instead of scalenus anticus syndrome.

The most significant paper published as regards etiology, pathology and clinical manifestations is the one by Swank and Simeone,<sup>29</sup> which appeared in 1944. They explained the symptom complex on the basis of the anatomy of the scalenus anticus muscles. From their anatomic investigations they clearly demonstrated that the tendons of origin of the scalenus anticus muscle from the third to the sixth cervical vertebrae are in direct relationship to the fourth to the seventh cervical nerve roots. The cervical nerve roots of the brachial plexus pass from the foramina along a groove in the transverse process to the tip of the process where the tendinous origins of the scalenus muscle are in direct contact with the nerve. The tendon arising from the tip of the third process passes over the fourth cervical nerve near the tip of the process. This continues downward until the last tendon arising from the sixth cervical transverse process passes over and is in contact with the seventh cervical nerve. The primary nerve roots, according to Swank and Simeone, increase in size from the fourth to the eighth, the sixth and seventh probably being the largest branches. As the nerve roots increase in size, they become more prominent in the groove of the transverse process; therefore, they are more closely in contact with the tendons of the scalenus anticus muscle. This is true of the sixth and seventh

cervical nerve roots, whereas the fourth and fifth, which are small, are seldom subjected to tendon pressure. The sixth and seventh nerve roots are liable to pressure and/or irritation by the scalenus tendons. Swank and Simeone believe that this is responsible for certain symptoms manifest in the scalenus anticus syndrome which they classified as the superior or upper type.

The description in the preceding paragraph is applicable only to the fifth, sixth and seventh cervical nerve roots. The relationship of the scalenus anticus to the eighth cervical and first dorsal roots, according to Swank and Simeone, is somewhat more complicated. The four tendons of origin of the anterior scalenus muscle coalesce into a comparatively broad muscle which is inserted into the scalenus tubercle of the first rib in front of the subclavian artery. The scalenus medius arises from the same transverse processes of the cervical vertebrae as the scalenus anticus but from their posterior aspect. The scalenus medius is inserted on the superior surface of the first rib just behind the scalenus anticus. Between the insertions of the scalenus anticus and scalenus medius there is a small triangle through which pass the cords of the brachial plexus and the subclavian artery. These structures are in direct association with the unyielding portion of the scalenus anticus and medius muscles and the first rib. Any encroachment upon this space will result in pressure upon the brachial plexus and subclavian artery. A cervical rib or a long transverse process of the seventh cervical vertebra will push the scalenus medius forward against the unyielding part of the scalenus anticus so as to produce a "squeeze" of the lower cords of the brachial plexus and subclavian artery. Hypertrophy of the scalenus anticus muscle likewise will cause pressure on the artery and lower cords of the brachial plexus. This resultant pressure produces vascular changes and brachial plexus neuritis. The symptom complex arising from pressure on the eighth cervical and first dorsal nerve roots as well as on the subclavian artery has been designated by Swank and Simeone as the inferior or lower type of scalenus anticus syndrome.

Our observations are in agreement with the anatomic findings of Swank and Simeone and their interpretation of the mechanism of nerve root pressure by the tendons of the scalenus anticus muscle in the superior type syndrome and the "squeeze" of the lower cords of the brachial plexus by the anticus and medius muscles. In this communication these findings will be supplemented by a preliminary

report of the findings of Reed\* and Weed,\* who at my suggestion made a detailed anatomic study of the scalenus anticus and medius muscles, the brachial plexus and the subclavian artery. In over 100 cadavers, they examined the origin and insertion of the scalenus anticus and scalenus medius muscles, the variations in the insertion of the scalenus anticus on the first rib, the variations in the angle between the scalenus anticus and scalenus medius muscles at the level of the first rib and the relationship of the upper and lower nerve trunks of the brachial plexus to the scalenus anticus and medius muscles as well as to the subclavian artery. In addition to the relationship of the tendons of origin of the scalenus anticus muscle to the fourth, fifth, sixth and seventh cervical nerves we found the upper cords of the brachial plexus passing through the scalenus anticus muscle in 30 per cent of the dissections. The incidence of the passage of the cervical nerves through the scalenus anticus muscle is shown in Table 1. It was surprising to find some of the cervical nerves passing through the scalenus medius muscle. (Table 1.) The fifth alone and the fifth and sixth together was the most common combination of cervical nerves to pass through the scalenus muscles. On the right side the upper roots of the brachial plexus passed through the scalenus anticus muscle nineteen times and on the left twenty times, making a total of 39 or 30 per cent, (Table 1) whereas the cervical nerve roots only passed through the right and left scalenus medius twice each, making a total of 4 or 3.1 per cent. The total cervical nerve roots passing through the scalenus anticus and medius was 43 or 33.5 per cent. (Table 1.) I believe that these anomalies play a prominent and significant role in the etiology of scalenus anticus syndrome of the superior type.

Another interesting finding was the presence of a scalenus anticus minor muscle in 60.8 per cent of cadavers dissected. (Table 11.) This muscle was found forty-one times on the right and thirty-nine times on the left; in twenty-five instances it was bilateral. The scalenus anticus minor split off from the scalenus anticus and passed downward and parallel to the posterior border of the anticus and inserted itself into the first rib between the subclavian artery and the lower roots of the brachial plexus. This finding is of great significance both from the standpoint of etiology and surgical treatment. It is possible that the cervical nerves that passed through the

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scalenus anticus may have passed between the scalenus anticus and minor. This point was not definitely established. Another possibility is that in the embryonic development the upper roots of the brachial plexus may have been responsible for the splitting of the scalenus minor from the anticus. Regardless of its method of embryologic

TABLE I  
NERVES PASSING THROUGH SCALENI MUSCLES  
Scalenus Anticus

Nerve	Incidence		
	Right	Left	Both
5 C.....	8	11	
6 C.....	1	1	
5 C and 6 C.....	8	8	
5 C, 6 C and 7 C.....	1	0	
8 C, 1 T.....	1	0	
Total.....	19	20	39 (30 %)

Scalenus Medius			
6 C.....	1 5 C	1	
7 C, 8 C, 1 T.....	1 5 C, 6 C	1	
Total.....	2	2	4 ( 3.1)%
		Total....	43 (33.5%)

TABLE II  
SCALENUS ANTICUS MINOR

Bilateral.....	25 (19.7%)
Right.....	41
Left.....	39
Total.....	80 (60.8%)

development, its presence certainly narrows the triangular space between the comparatively rigid scalenus anticus and medius muscles. Therefore, changes in any of the three muscles (anticus major, minor or medius) will result in pressure upon the brachial plexus. In fact, Falconer and Weddell<sup>7</sup> reported a case of scalenus anticus syndrome which was demonstrated at operation to be due to compression of the first dorsal nerve against the neck of the first rib by a scalenus minimus muscle. In their case there was a groove in the nerve where it was compressed by the scalenus minor muscle.

Section of the scalenus minimus relieved all symptoms. They stated that the symptoms were not due to the scalenus anticus muscle.

Other significant variants noted in our dissections were the inconstancy in the size of the scalenus anticus muscle as well as the location of its attachment to the first rib as regards the distance from the sternoclavicular joint to its insertion. This latter variation also had a direct bearing upon the width of the base of the triangle between the scalenus anticus and medius muscles. The width of the scalenus anticus muscle varied from 0.6 to 2.5 cm. The base of the triangle or distance between the posterior border of the scalenus to the anterior border of the medius varied from 0.3 cm. to 2.3 cm. One can easily predict the difficulties a patient would have with a narrow triangle containing the brachial plexus, subclavian artery and scalenus minimus muscle. The insertion of the medius remains more or less constant. The narrowing of this triangle also depends on the distance from the costosternal junction to the insertion of the scalenus anticus muscle which varied from 2.5 cm. to 6 cm. If the distance is short, the triangle is large but if great the triangle is small. Therefore, the greater the distance from the costosternal junction of the first rib to the insertion of the scalenus anticus, the narrower the triangle between the scalenus anticus and medius muscles.

The relationship of the subclavian artery to the scalenus anticus major and minor was more or less constant. The artery was posterior to the scalenus anticus except in one case in which it came through the anticus muscle. In the majority of instances the scalenus anticus minor was posterior to the artery. There were, however, a few cases<sup>6</sup> in which the scalenus minor circumscribed the artery as a loop or joined the scalenus anticus tendon beneath the artery. It is also worthy of note that the cords of the brachial plexus were so located between the subclavian artery and scalenus medius that compression of the so placed nerves could easily occur; this was noted twenty-one times on the right and twenty-six times on the left.

The subclavian artery in a number of instances was so situated anatomically in relation to the scaleni muscles and the first rib that compression or irritation could easily take place. However, complete obliteration of the artery seldom if ever takes place in simple scalenus anticus syndrome. Greater compression of the artery and even obliteration occur in cases with cervical ribs. The same is also true in the costoclavicular syndrome described by Falconer and Weddell<sup>7</sup> and Eden.<sup>8</sup> According to these authors the latter syndrome

may produce obliterative arterial disease of the upper extremities. The production of subclavian compression and even those cases of aneurysm of the subclavian artery in association with cervical rib is due to compression of the subclavian artery between the clavicle and the first rib. Falconer and Weddell<sup>7</sup> state that the "costoclavicular subclavian artery" syndrome can be produced by backward and downward bracing of the shoulder with hyperextension of the neck. They investigated this peculiar phenomenon in fifty normal men and fifty normal women. Obliteration of the pulse occurred in twenty-five of the men and thirty of the women. They also stated that in these cases, section of the scalenus anticus under local anesthesia did not prevent the occurrence of this syndrome. They, therefore, had to resect a portion of the first rib to allow the artery and brachial plexus to sink into this artificially created gutter. This increased the angle between the clavicle and first rib and prevented pressure on the subclavian artery. Eden<sup>6</sup> in 1939 collected forty-eight cases of obliterative arterial disease due to the costoclavicular syndrome. This is mentioned in connection with the scalenus anticus syndrome because if severe vascular disturbances are present in the latter syndrome, one should suspect costoclavicular pressure since simple scalenotomy will not correct this anatomic anomaly. Smith,<sup>27</sup> however, reported a case of thrombosis of the subclavian artery associated with scalenus anticus syndrome which was relieved by section of the scalenus anticus muscle. In the light of Eden's<sup>6</sup> and Falconer and Weddell's<sup>7</sup> reports, this case of Smith's<sup>26</sup> was probably the result of costoclavicular subclavian compression. Severe arterial symptoms, therefore, seldom occur in simple scalenus anticus syndrome but do occur in the presence of cervical ribs and the costoclavicular subclavian syndrome.

From the preceding anatomic descriptions of the normal and abnormal relationships of the scaleni muscles, brachial plexus nerve roots and the first rib, definite conclusions can be drawn regarding the relationship of these structures to the clinical manifestations of the scalenus anticus syndrome. These are: (1) there is a definite relationship between the tendons of the scalenus anticus and the fifth, sixth and seventh cervical nerves, (pressure producers), (2) there is a scalenus anticus minor muscle in 60 per cent of cases; (3) the upper roots of the fifth, sixth and seventh cervical nerves (singly or in pairs) pass through the scalenus anticus muscle or between the scalenus major and minor; (4) the unyielding scalenus anticus and scalenus medius at their attachment to the first rib forms a slit-like

triangle between the two muscles and the first rib; (5) there is a decrease in this triangle by the insertion of the scalenus minor muscle between the artery and brachial plexus; (6) there is a variation in width of the scalenus anticus muscle (0.6–2.5 cm.), in the distance from the costosternal junction to insertion of the scalenus anticus muscle (2.5 to 6 cm.) and in the width between the scalenus anticus and medius (the scalenus triangle) 0.3 to 2.3 cm. and (7) there is an anatomic relationship between the brachial plexus, subclavian artery, and the first rib in this triangle. These factors create an ideal anatomic arrangement for the occurrence of neurovascular and scalenus anticus disturbances in a moderately high percentage of persons. However, there must be some factor or factors not well understood that act as the initiating spark which sets in motion the pathologic anatomy responsible for the appearance of the scalenus anticus syndrome. There are many explanations regarding the precipitating factors responsible for the occurrence of the symptoms. It is agreed by the majority of authors that pressure upon the brachial plexus is responsible for the symptoms and that the scalenus anticus muscle (to this I would add the scalenus anticus minor) is the offending structure in the majority of, if not all, cases. The truth of this assertion has been repeatedly proved by the relief of symptoms following section of the scalenus anticus muscle. Section of the muscle results in detachment of its lower fixed end so that if the muscle goes into spasm, it cannot become taut and consequently, its "squeeze" effect is lost. Thus, it can specifically be stated that the primary disturbance occurs within the scalenus muscle, and I believe, in the majority of cases the precipitating factor is trauma, which need not necessarily be severe. That traumatic myositis of the scalenus anticus muscle can and does produce the syndrome has been reported by Aynesworth.<sup>1</sup> In all the sections of the scalenus anticus which we studied we found microscopic evidence of inflammation, hypertrophy and degeneration. The trauma may disturb the tendinous attachments resulting in spasm of the muscle heads or it may produce minute hemorrhage which would cause irritation of the sixth and seventh nerve roots in their groove beneath the tendons and muscle. This would produce the symptom complex of the superior type, whereas the spasm and tenseness of the scalenus anticus and the minor muscles would squeeze the lower cords of the brachial plexus between the scalenus anticus or scalenus minor or both and the scalenus medius. Once this action is set in motion, the muscle spasm plus the cervical nerve root irritation and the increase



in the brachial plexus compression, increase the spasm resulting in hypertrophy of the muscle which increases the nerve irritation resulting in a vicious circle. As Aynesworth<sup>1</sup> stated, "Many, if not all, of the diseases in this small region [scalenus triangle] are the result of developmental defects." This statement is in agreement with Todd,<sup>30</sup> Jones,<sup>13</sup> Ochsner, Gage and DeBakey,<sup>23</sup> Swank and Simeone<sup>29</sup> and many others as well as the author's present statements based upon his anatomic studies and those of Swank and Simeone.<sup>29</sup>

Thus, it may be stated that the three factors (1) a congenital anomaly, (2) trauma (slight to severe) and, (3) traumatic myositis and hypertrophy of the scalenus anticus muscle, resulting in compression of the roots of the brachial plexus, synchronized into one motivating expression will result in a pattern which produces the clinical manifestations of the not too well known scalenus anticus syndrome.

The disease occurs more commonly in women than men. In Jelsma's<sup>12</sup> review of 194 cases 56 per cent were in females. This preponderance of females is not easily explained, except that there may be more minimal and constant trauma to the scaleni in women than in men. Most women are first cognizant of the disease while doing house work.

The clinical manifestations may be protean but usually maintain a more or less constant pattern. In the majority of cases reported pain was felt along the distribution of the ulnar nerve with other signs and symptoms in the neck and shoulder girdle. We<sup>23</sup> considered this to be an overflow of impulses to other portions of the brachial plexus due to continuous and excessive stimulation of the lower cord. This rather wide distribution of the signs and symptoms has been thoroughly investigated by Swank and Simeone.<sup>29</sup> They concluded that there are two types of scalenus anticus syndrome: (1) the superior or upper type and (2) the inferior or lower type. It was only by thorough neurologic examination that they were able to classify the syndrome into two types. They were the first to describe the superior type, and called attention to the fact that it has not been correctly diagnosed. They further subdivided the superior syndrome into three types. In the first type the onset was sudden (within a period of hours) and the signs and symptoms practically complete within the first forty-eight hours. The characteristic clinical manifestation was severe weakness or paralysis of the extensors of the wrist and fingers producing wrist drop. There was numbness and tingling in the thumb and index finger and occasionally the long finger

spreading to the radial side of the hand. Reduced sensitivity to pin prick and cotton was noted in the areas of numbness and tingling. There was also decreased deep sensation in the first interosseous muscle. The numbness was first noted either in the thumb or index finger. If it started in the thumb first, it spread to the index finger and vice versa. Swank and Simeone noted that the signs and symptoms changed from day to day, but "the pattern of spread and the regression of the sensory signs remained constant." Wrist drop was a constant finding and if the muscle weakness of the extremity had not been tested it would have been labeled radial nerve paralysis. However, it was found that there was little demonstrable weakness of the muscles of the arm and only slight weakness in the supinators of the forearm. The weakness was always less in the supinators than in the extensors of the wrist and fingers. This with other muscle weakness separated the clinical picture from true radial paralysis. In patients with wrist drop and tingling and numbness of the thumb, index finger and radial side of the hand, pain and muscle spasm was conspicuous by its absence. Here we have a syndrome characterized by numbness and tingling, decreased sensitivity and muscle weakness amounting to paralysis without pain or muscle spasm.

The clinical manifestations of the second type of the superior form differ entirely from the first type and from the lower type to be described later. In the second type the predominating feature is pain and muscle spasm, ranging from mild to severe. The pain usually has recurred over a period of several months and is somewhat periodic in type. It is located in certain definite areas: the extensor surface of the forearm, the dorsal surface of the upper part of the arm, the posterior axillary fold, the tip of the shoulder, the neck, and the area medial to the scapula. The rhomboids, deltoid, triceps extensors of the wrist and fingers and the teres major may be involved. The pain is localized in the muscles and may be severe or aching. The muscles are usually tense or in spasm and frequently contain localized, tender knotty areas. In cases with severe muscle spasm the head may be tilted toward the involved side and the concomitant shoulder is frequently elevated. Occasionally, the affected shoulder seems to sag; this is thought to be due to relaxation of the muscle spasm. There are tender areas in the neck in this type, the most constant points being localized over the fourth, fifth and sixth transverse processes corresponding to the tendinous origin of the scalenus anticus. Another point of tenderness is found over the lower portion of the scalenus anticus muscle near its insertion into

the first rib. The entire scalenus anticus muscle may be tense and painful. In their cases of this type Swank and Simeone<sup>22</sup> were unable to demonstrate muscle weakness or sensory changes. However, some of their patients gave a history of numbness and tingling in the index and middle fingers.

Swank and Simeone had two patients to present a combination of the preceding two types characterized by muscle weakness, pain and muscle spasm with sensory changes in the areas of numbness and tingling. The distribution of the changes was similar but to a less degree with almost identical patterns as the two types already described.

The inferior or lower type is the syndrome that has been so frequently reported in the literature. The clinical manifestations are due primarily to irritation of the eighth cervical and first dorsal nerve roots of the brachial plexus. The onset is gradual and as a rule extends over a period of several months. The character of the numbness, muscle weakness and pain is more uniform and therefore more easily diagnosed than the superior form. The pain may be mild to severe and is usually in the neck (scalenus anticus), along the inner aspect of the arm and forearm and along the ulnar side of the hand, little and ring fingers. The sensory changes noted on pin prick and light touch are along the ulnar border of the hand and ring and little fingers. Occasionally, the ulnar side of the forearm has sensory changes which may creep toward the radial side of the forearm and hand. There is definite weakness of the muscles of the hand, especially the ring and little fingers resulting in a weak grip.

There may be atrophy of the intrinsic muscles of the hand with trophic changes in the overlying skin. There is not the marked weakness in the lower group as found in the superior group; occasionally there may be manifestations of weakness of the extensor muscles of the wrist and fingers. The pain may be so severe that the arm is confined to a sling. The pain can be reproduced if the scalenus anticus muscle is tensed by certain movements, such as turning the head to the affected side or sweeping. Patients frequently get relief by elevating the arm over the head and often sleep in this position. Occasionally, these patients may have some of the signs and symptoms of the upper syndrome; this can only be determined by a thorough neurologic examination.

The vascular changes are mild in the scalenus syndrome. They are more constant and prominent in cases with cervical ribs<sup>19,23,5</sup> and patients with the costoclavicular syndrome.<sup>6</sup> However, vascular

changes and vasomotor disturbances are common in the lower syndrome of the scalenus anticus type. There is a diminution in pulsation of the radial and ulnar arteries as shown by the Tycos recording sphygmomanometer. We<sup>11</sup> found this to be the most accurate method of determining vascular changes. Turning the head toward the affected side with chin extended causes a diminution to obliteration of the radial pulse. We<sup>23</sup> originally considered this to be of diagnostic importance but now disregard it, as 50 per cent of normal people exhibit a similar phenomenon on turning their head toward either side.<sup>29</sup> However, I had one patient who had unilateral symptoms of Raynaud's disease even to gangrenous areas on the tips of the fingers. The condition was relieved by scalenotomy.

The diagnosis of scalenus anticus syndrome is not difficult if the syndrome is constantly kept in mind when patients with pain in the upper extremities are examined. However, if only the lower or inferior type is recognized, the superior type will be completely missed. In patients with sudden wrist drop without a history suggestive of radial nerve injury the superior type should be considered. All patients with pain in the neck, shoulder, arm and forearm with numbness and tingling in the thumb, index, ring or little fingers, associated with muscle weakness should have a thorough neurologic examination of the muscles and nerves of the involved extremity. This in itself will eliminate a number of conditions with symptoms similar to the scalenus syndrome. The muscles of the neck, shoulder girdle, and upper extremity should be thoroughly palpated for painful and sensitive areas. The scalenus anticus muscle on the involved side is painful to palpation and pressure in 100 per cent of the patients exhibiting the syndrome. If pain is not present on pressure over the lower portion of the scalenus anticus muscle, the patient probably does not have scalenus anticus syndrome. The entire upper extremity should be investigated for sensory disturbances to pin prick and light touch, vascular disturbances, blood pressure changes and diminution of radial pulse on turning the head with the chin extended to the affected and unaffected sides.

A diagnostic test first described by me in 1939<sup>8</sup> and later confirmed by Kaplan<sup>18</sup> and Judovich and Bates<sup>15, 16, 17</sup> has been of inestimable value in diagnosing the scalenus anticus syndrome. The test consists of injecting 5 to 10 cc. of a 1 per cent solution of procaine hydrochloride into the scalenus anticus muscle. Care must be taken not to inject the phrenic nerve or the stellate ganglion. In reporting the use of this test both Kaplan<sup>18</sup> and Judovich and

Bates<sup>15, 16, 17</sup> obtained a Horner's syndrome following the injection. This should be avoided as it negates the test. The test is accomplished in the following manner. The patient can be either in a sitting or recumbent position. The head is turned toward the unaffected side in the recumbent position and only slightly so in the sitting position. The edge of the scalenus anticus muscle is palpated with the left thumb and while the left thumb and forefinger steady and isolate the muscle, a small needle is passed through a wheal of procaine hydrochloride in the skin into the anterolateral edge of the scalenus anticus muscle. Five cubic centimeters of a 1 per cent solution of procaine hydrochloride is injected upward and downward into the muscle belly. This produces relaxation of the scalenus muscle and relieves the symptoms. Therefore, not only is the test diagnostic but it proves that spasm of the scalenus anticus is present in scalenus anticus syndrome in the active stage.<sup>23</sup>

The differential diagnosis is not difficult; however, this entity must be differentiated from subacromial bursitis, brachial plexus neuritis, arthritis of the cervical spine, herniated cervical disk, rupture of the supraspinatus tendon, sympathalgia of the cervicodorsal type and cervical rib. Any acute lesion about the shoulder joint (most commonly bursitis) may produce spasm of the shoulder girdle muscles; however, sensory disturbances are absent and there is no weakness of the muscles of the forearm. Roentgenograms help by demonstrating subdeltoid calcification, cervical rib and all forms of bony lesions of the cervical spine. Probably the one lesion whose symptoms simulate scalenus anticus syndrome more closely than all others is herniation of a cervical disk. This lesion is rare; the pain beside radiating into the arm is precordial, closely simulating angina pectoris. This is seldom encountered in scalenus anticus syndrome. We have had one patient at the Clinic with precordial pain (treated for heart disease for twenty years) who was relieved by scalenotomy. In herniated disk with root pain injection of the scalenus muscle will not relieve the pain. We had two patients who did not obtain relief following injection of the muscle; nevertheless, both were operated on and the symptoms persisted. The differentiation of other lesions from the scalenus anticus syndrome is simple but the diagnosis of the causative lesion is difficult.

The treatment of the scalenus anticus syndrome is conservative or radical. The majority of authors agree that conservative treatment should be tried first in the acute and mild cases. If con-

servative measures fail, section of the scalenus anticus muscle is indicated.<sup>1-13, 15-29, 31, 32</sup>

The conservative treatment consists in correction of poor posture, massage, diathermy, rest of the upper extremity, injection of the scalenus anticus muscle with procaine hydrochloride and sleeping on three pillows as recommended by Reichert.<sup>26</sup> Swank reported that six cases out of seventeen were successfully treated by conservative measures. Spurling<sup>28</sup> reported that 300 cases out of 400 responded to conservative treatment and Reichert<sup>26</sup> reported that of seventy-four patients sixty obtained relief without operation. This clearly demonstrates that every patient with pain in the neck and shoulder radiating into the arm does not need a scalenotomy.

If conservative treatment fails to relieve the symptoms, scalenotomy with partial resection of the scalenus anticus muscle is indicated. The technic of the operation has been adequately described in a previous communication.<sup>23</sup> The operation is usually performed through a limited transverse incision about 1 cm. above the clavicle on the affected side. A more liberal incision would permit visualization of the anomalies in this area. In the smaller transverse incision one is unable to visualize the anomalies and other precipitating anatomic factors described in the discussion of the anatomy. I would, therefore, suggest that a somewhat triangular incision be made—one that begins along the lateral border of the sternocleidomastoid muscle and then extends transversely across the supraclavicular fossa. Or, the transverse incision as practiced today can be turned upward along the lateral border of the sternocleidomastoid muscle if visualization is incomplete through the transverse incision. With this wider exposure the lower origin of the scalenus anticus can be visualized and the presence of a scalenus minor and the passage of the brachial plexus roots through the muscles can be thoroughly inspected. During dissection about the brachial plexus one must be most gentle in elevating or retracting the cords of the plexus out of the immediate operative field. If the surgeon is not gentle, traumatic brachial plexus neuritis will result and persist for months after operation. The symptoms of this form of neuritis will closely simulate the preoperative symptoms of the syndrome and the operation will be labeled a failure. The patient can be up the same or next day after operation and discharged to his home on the third or fourth postoperative day. Full activity can be resumed in about a month.

Fluoroscopy should be done before the patient is discharged from the hospital to detect the presence of limitation of the diaphragm on the side of the operation. I am convinced that we will find a rather high percentage with decreased movement of the diaphragm due to operative trauma to the phrenic nerve.

If the candidates for operation are carefully selected, the results should be uniformly good. If the tissues, especially the brachial plexus, are traumatized, the results will be poor.

It is hoped that this presentation will stimulate further anatomic investigations of the scaleni muscles, brachial plexus, subclavian artery and their relationships both in the cadaver and in clinical cases. There is a definite need for such studies for a more thorough understanding of the factors responsible for this interesting clinical syndrome.

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#### DISCUSSION

ARTHUR R. METZ (Chicago): Scalenus anticus syndrome is a condition which is being overlooked or unrecognized by a number of physicians and it was very instructive to hear Dr. Gage's fine presentation which has helped clarify this condition.

I had a very startling result in a dentist who was considering giving up his work on account of numbness in his fingers of the right hand associated with inability to handle his instruments. It was found that by pressing on his scalenus anticus muscle a definite local pain was produced. The muscle also seemed abnormally tight as compared with the opposite side. His radial pulse was also shut off when the arm was placed straight up and backward. A scalenus anticus syndrome was diagnosed. Severing of the muscle and removal of a portion gave him prompt relief.

We feel greatly indebted to Dr. Gage for giving us such a clear and fine presentation.

CASPER F. HEGNER (Denver): I certainly hope you all appreciate how important this contribution by Dr. Gage is in clearing up the scalenus anticus syndrome. I happen to have a family of three, a mother and two



daughters, who have the ascending type of chest, looking almost as though it was being drawn through their shoulder girdle; they all have very long necks and all of them have this disturbance.

The trophic disturbance of the finger nail is very classic in this. I do not know if Dr. Gage has noticed it. Rest and change of occupation of the two girls eliminated all the symptoms.

It is an important thing that rest must be had. I have operated on these conditions two or three times, and I want to emphasize the fact that a section of the muscle must be taken out, otherwise there will be a recurrence.

HENRY C. MARBLE (Boston): I have a couple of questions which I am glad to ask Dr. Gage.

First, numb fingers are common and basic in the hand clinic. One of the reasons is the scalenus syndrome. There are many others. One patient with numb fingers had all of Dr. Gage's syndrome, but in addition to that the patient had trapezius paresis. We therefore believed it was a cervical disc. After a great deal of study we explored the cervical region and it was negative. We then got the scalenus and the patient got well. I would like him to explain that. It is difficult.

The scalenus patients whom I habitually see come into the office and give their history holding their hands above their head. I say, "What do you do that for?" They say, "That is the only way I can be comfortable."

Do they do that in New Orleans, Doctor? They come in and give me a history of their trouble, standing up like this.

I took out a few and more recently all the patients I have had have been given exercises to strengthen their shoulder muscles, shoulder elevation exercises and to my joy some of them have been temporarily relieved. I wonder if that has been your experience.

It may be that as patients grow older their muscles grow weaker and the whole shoulder girdle sags, and it precipitates these variations which Dr. Gage has described and certainly in my hands a few of the patients have become better after we have restored the muscle tone, the muscle power, of their shoulder girdle.

MIMS GAGE (closing): I wish to thank the discussers very much. I am very sorry I can't answer Dr. Marble's question.

# DEFORMATIONS OF THE SKULL IN HEAD INJURY AS STUDIED BY THE "STRESSCOAT" TECHNIC

E. S. GURDJIAN, M.D. AND H. R. LISSNER, M.D.\*

DETROIT, MICHIGAN

DEFORMATIONS of the skull resulting from trauma were studied by Felizet<sup>1</sup> and Bruns<sup>2</sup> in the latter part of the nineteenth century by crude and inaccurate methods. With the turn of the twentieth century, most research on craniocerebral trauma concerned the brain, and during the past fifty or more years, little has been done about the mechanism of injury to the bony covering of the brain. The common statement that "it is not the injury to the skull, but to the contents of the skull that counts," although perfectly correct, has had its influence upon the type of research planned. Therefore it is not surprising that with the exception of the contributions of LeCount and Apfelbach,<sup>3</sup> there has been little research of consequence on the mechanism of the causation of fractures in trauma. In the past three years, our group has had access to newer technics for the study of deformations of the skull and the time period of the disturbance following trauma<sup>4,5</sup> and we have been fortunate in having at our disposal the "stresscoat" technic about which the present contribution is written.

By the "stresscoat" technic the surface of the skull is coated with a strain-sensitive lacquer. Cracks form in the lacquer when the skull is subjected to tensile strains of fifty hundred thousandths to one hundred and fifty hundred thousandths of an inch per inch. By this method deformation patterns may be studied in the immediate vicinity of, as well as remote from the region of the blow. Different lacquers are used for different temperature and humidity conditions.

In a previous paper the experimental work concerning correlations between the living and the dry skull has been described.<sup>6</sup> It was found that the strain patterns obtained in the dry skull were smaller in magnitude than in the skull of the dead animal or that of the animal under anesthesia, but the direction and general distribution of the patterns were the same in all three classes. It was con-

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cluded that the findings on the dry skull were similar to those in the living skull. In the study of the human material, dry and cadaver skulls were used. The skull of the human and the lower forms differed materially in their strain patterns. In the human, the deformations detected by this technic were more localized.

At the outset it must be stated that this method has certain limitations. It shows only tensile (tearing apart) strains. Thus far we have studied the behavior of the outer surface of the skull and have no information concerning what happens on the inner surface. The method necessitates the removal of the skin and muscles so that their effect on deformations cannot be determined. However, having found that the contents of the skull have practically no effect on the direction and path of tensile strains, it is justifiable to deduce that the removal of the skin and muscles from the exterior of the skull would be of minimal significance, if any. In the human dry skull, suture lines affect to some degree the transfer of strain patterns.

#### PROCEDURE

Monkeys and dogs were used to establish a correlation between the dry skull, the skull of the dead animal with contents intact, and the skull of the animal under anesthesia. The human studies were done on dry and cadaver skulls. Since it was found that suture lines in dry skulls tend to interrupt the propagation of the cracks in the lacquer, it was decided to keep the skulls moist, in certain experiments, by immersing in normal saline solution between tests to prevent the disintegration of the material at the suture lines.

The technic of the application of the "stresscoat" is given briefly. In the experiment animals, the scalp and temporal muscles were dissected away and the surface of the skull was allowed to dry for about thirty minutes. After the application of ether to remove some of the surface organic matter, aluminum undercoating, followed by the "stresscoat" lacquer was sprayed on the skulls. The lacquer was permitted to dry for four hours. Then hammer blows were administered and the deformation pattern was developed with red dye etchant solutions. All this work was done under nembutal anesthesia up to this point. Here the animal was sacrificed, and after a study of the strain paths, the lacquer was cleaned away from the skull, and twenty-four hours later another "stresscoat" test was made on the dead animal with the contents of the skull intact. After this test, the skull was removed, completely cleaned and dried, and a

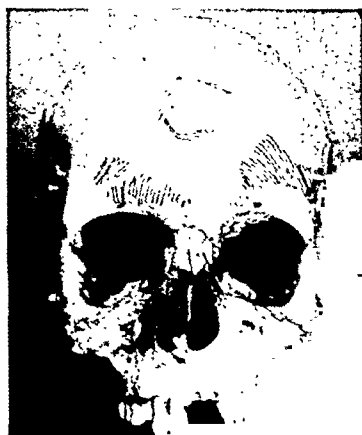
third "stresscoat" test was made. In all three instances the blow was struck in the same location on the skull. It was found that the direction of the strain paths in all three classes was essentially the same.

In the human material, cadaver and dry skulls were used in order to study the effect of blows in certain locations. In one group of experiments, dry skulls were used and the effects of hammer blows in various regions were studied. The blows were delivered to the midfrontal, midoccipital, lateral frontal, lateral postero-parietal, and anterior midline vertex regions. Some quantitative work was done with human skulls freshly obtained from the anatomical laboratory and cleansed of coverings and contents. Some of the latter were kept in saline solution between tests.

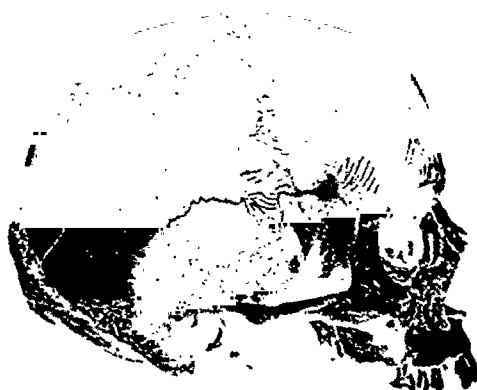
For the quantitative tests the skulls were removed from the saline solution several hours before coating in order to permit the excess moisture to drain off and evaporate. Just before spraying, they were washed with ether. The lacquer adhered to the surface of the skull with no difficulty. Initially a uniform undercoating of aluminum lacquer was applied, and after fifteen minutes the "stresscoat" lacquer was sprayed on. Several calibration strips were coated at the same time. The lacquer was allowed to dry for twenty-four hours before testing. In order that the results of the tests made at different times could be correlated, it was necessary to have the strain-sensitivity of the lacquer within certain limits for these experiments. The range chosen was on hundred hundred-thousandths, plus and minus five hundred-thousandths of an inch-per-inch of strain to produce cracks in the lacquer. When the test was about to be made, one of the calibration strips was tried to check the strain-sensitivity of the lacquer for the existing temperature and humidity conditions of the room. If the sensitivity was too great, the room temperature was increased until a calibration strip test showed that the sensitivity was not less than ninety-five or more than one hundred and five one-hundred-thousandths of an inch per inch. The skulls were then tested. A room with constant temperature and humidity conditions would obviate some of the above described conditions. However, with the use of the calibration strips, an accurate and quantitative determination can be obtained. In order to control the amount of energy absorbed by the skull, they were dropped onto a polished steel block weighing several hundred pounds. The weight of the skull and the distance through which it was dropped determined the amount of energy absorbed by the



A



B



C

FIG. 1. "Stresscoat" preparation following midfrontal blow. Note the strain patterns along the supraorbital ridges and the lateral aspect of the frontal bone and temples.

skull. Each skull was supported so that the blow was delivered perpendicular to a plane tangent to the point of impact.

The strain lines were developed by coating the lacquered skull with red dye etchant. The excess etchant was removed with an emulsifier solution, leaving the dye only in the cracks. In order to photograph them, the cracks were outlined with India ink and in the quantitative work, faint cracks were gone over more lightly than heavy cracks which were stained with heavy lines of ink.

#### EXPERIMENTAL DATA

The material will be given under three classes. First, results obtained with hammer blows in various locations; second, results

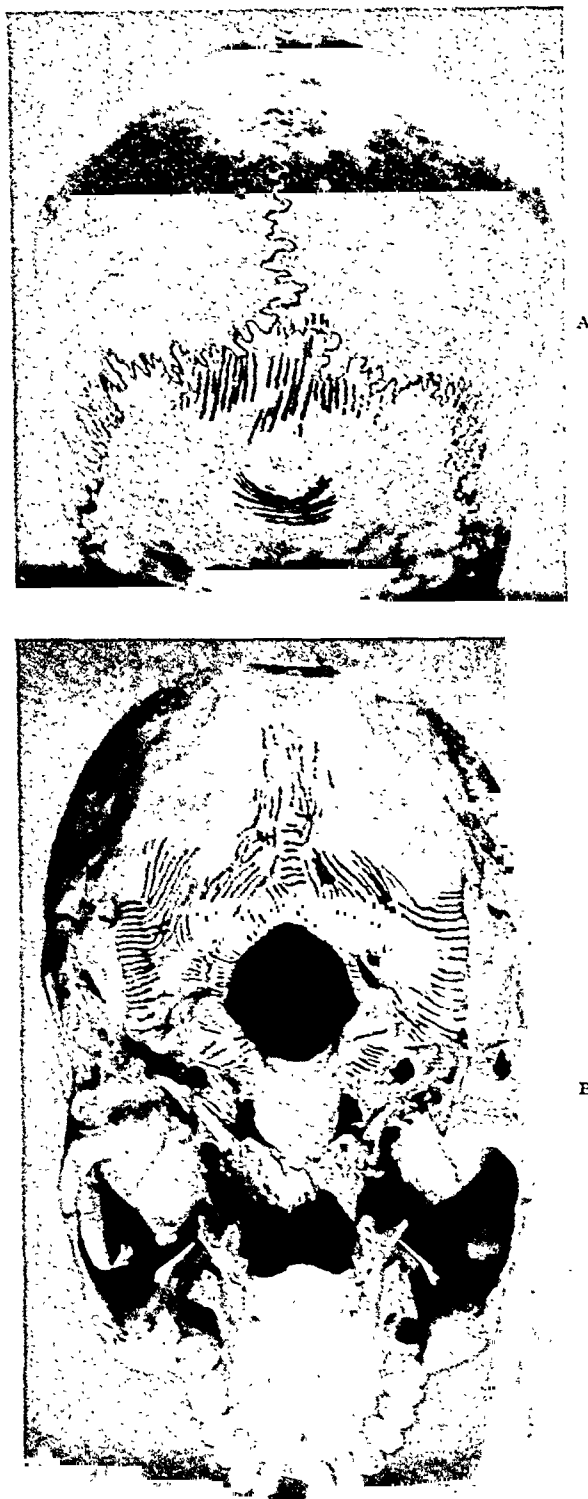


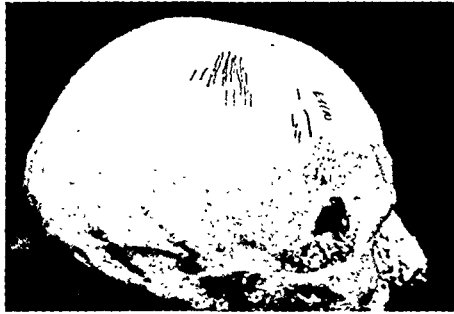
FIG. 2. "Stresscoat" preparation following mid-occipital blow in a dry skull. Note the lines of crack in the lacquer extending down toward the foramen magnum with some curving outward.



FIG. 3. "Stresscoat" preparation following a lateral frontal blow in a dry skull. The lines of crack extend downward almost perpendicularly toward the temple.



FIG. 4. "Stresscoat" preparation following a posterior parietal blow in a cadaver preparation. The cracks in the lacquer extend downward and forward in the temple.



A



B

FIG. 5. Midfrontal blow at the bregma causing cracks in the lacquer extending perpendicularly downward toward both temples.

obtained with blows of constant energy; and three, results obtained with blows of varying energy.

*Results Obtained with Blows in Various Locations.* In the human skull it was found that blows in the midfrontal region were followed by strain paths extending down to the orbital rim and into the roof of the orbit, as well as cracks in the lacquer in the fronto-sphenoidotemporal region. (Fig. 1.) With midoccipital blows, near the lambdoid suture, there were cracks in the lacquer extending down toward the foramen magnum with many evidences of deformation about the foramen. (Fig. 2.) Lateral frontal blows caused strain paths extending downward and posterially toward the temple. (Fig. 3.) Lateral posteroparietal blows caused cracks which extended downward and forward toward the temple. (Fig. 4.) Blows at the bregma caused cracks in the lacquer extending perpendicularly downward toward each temple. (Fig. 5.)



FIG. 6. Contrecoup deformations sufficient to crack the lacquer at the zygomatico-fronto-sphenoid junction on both sides following a midoccipital blow. This was obtained in one out of thirteen skulls studied.

*Results with Constant Energy.* The application of 14.3 inch-pounds of energy by the method of dropping the skull onto the polished surface of a steel block resulted in patterns of different magnitude in different locations. Following midoccipital blows, the deformations were more extensive. With the same amount of energy, midfrontal blows resulted in little or no change. There was also some difference in magnitude of patterns obtained with blows at the same location but in different skulls. Such variations from skull to skull may be explained in part by differences in shape, contour and thickness, and slight change in the location of the blow in successive tests.

*Results with Varying Energies.* Energies varying from 8 to 24 inch-pounds were used. In order to obtain more reliable information, varying energies were used in different locations on the same skull. Whereas in the occipital region, 8 inch-pounds of energy caused threshold deformations, in the midfrontal region, 14 to 18 inch-pounds of energy was necessary to obtain beginning cracks in the lacquer. Threshold deformations were obtained with 10 inch-pounds following lateral posteroparietal blows.

#### COMMENTS

The human skull is well suited for study with the "stresscoat" technic. After convincing experimental data it was concluded that deformation patterns in the dry skull are the same as in the living. The influence of scalp and muscles on the strain path is negligible. This method shows only tensile strains. Compression strains cannot be visualized. Only the behavior of the external surface of the skull has been studied thus far. Tensile strains of the internal surface are



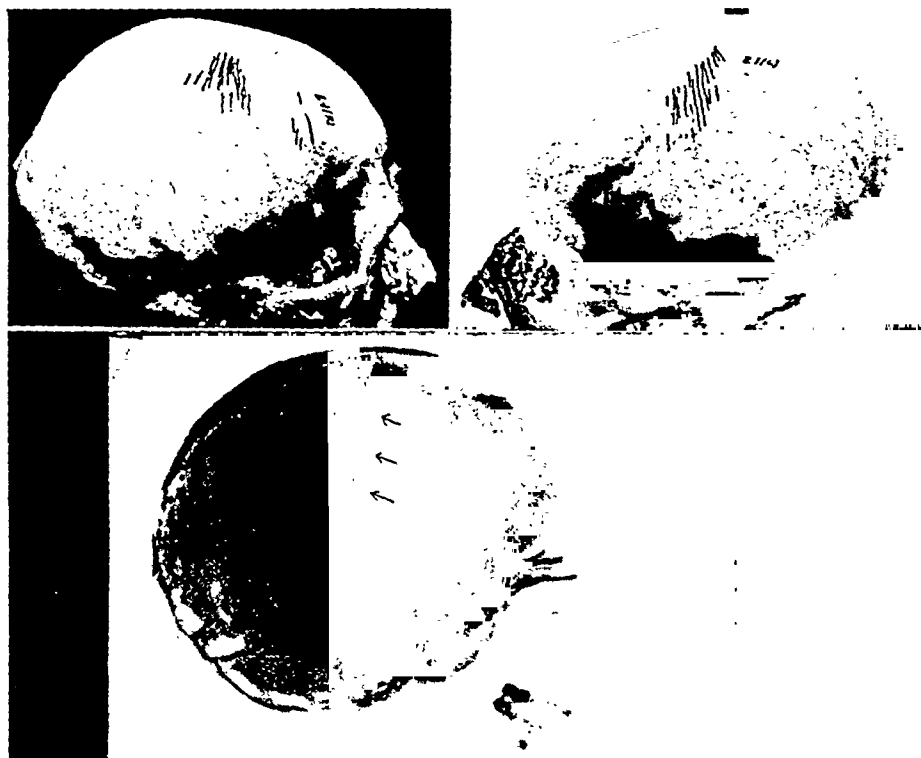


FIG. 7. Upper row of figures show "stresscoat" preparation in a cadaver following a blow at the anterior mid-line vertex. The cracks in the lacquer, which have been gone over with India ink, extend downward toward the temple. Below is seen x-ray film showing a fracture line extending from vertex downward toward the temple in a direction paralleling the strain patterns above. Note that the fracture is more widely separated at the vertex. It is reasonable to assume that the area of impact causing this fracture was at the mid-line vertex.

doubtless important following certain severe blows. Strain patterns may vary depending upon the location of the blow and small changes in location may produce altogether different paths of deformation. More work is needed to learn in greater detail the behavior of the skull to blows of varying location.

The strain paths depend upon the shape, contour, and thickness of the skull. Certain "chance" differences in skull thickness may produce profound differences in patterns. In our experiments, hammer and deceleration blows have been used. Actually, in automobile accidents and falls there may be a combination of energies operating on the skull in succession or simultaneously in more than one location. Depending upon the velocity of the blow, deformation patterns may be given a certain directional quality. High velocity energies may cause localized deformation with comminution, de-

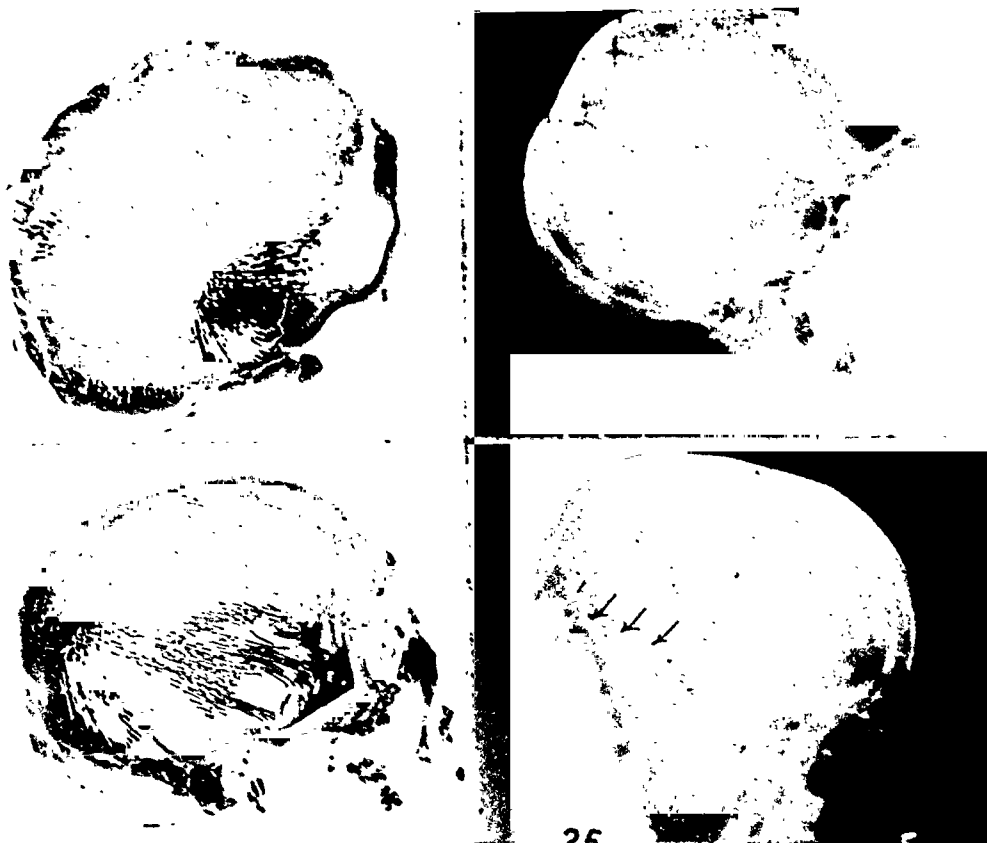


FIG. 8. To the left, "stresscoat" preparation in a dry skull following a posteroparietal blow. Note that the direction of the cracks in the lacquer are downward and forward toward the temple. To the right are two x-ray films with fracture lines extending downward and forward toward the temple from a posterior parietal region. The upper x-ray film also shows a depression of the posteroparietal region at the mid-line. It is reasonable to assume that the point of impact was in this region, with resultant depression and also fracture lines extending downward and forward toward the temple on both sides, paralleling the "stresscoat" lines of crack. In the lower x-ray, the fracture is more widely separated in the parieto-occipital region near the mid-line. This is the region of the greatest stress from the blow, with the fracture extending downward and forward, eventually becoming a thin line, to disappear in the temple.

pression or perforation of bone. At the present time, we have no information concerning the behavior of a skull with energies of high velocity. In the present study, velocities at the instant of impact varied between 5.4 and 9.9 feet per second.

In general, the paths of strain brought out by these studies parallel fracture lines seen clinically in the human. The deformation patterns are more common in the weaker than in the buttressed zones of the skull.<sup>8</sup> Thus, very few cracks are seen in the lacquer extending longitudinally along the median plane of the frontal and occipital bones. Relatively few deformation patterns are seen along the zygomaticofrontal and the petrosoparietal buttresses. Clinical

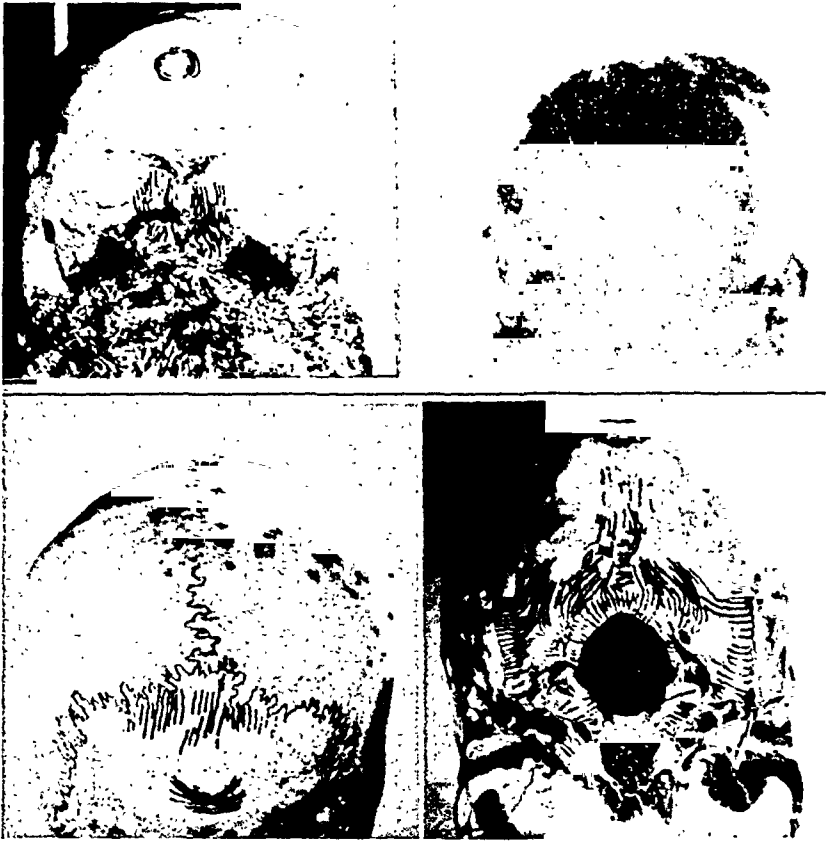


FIG. 9. "Stresscoat" preparation in a cadaver skull and two views of a dry skull following a midoccipital blow. Note the direction of the cracks in the lacquer toward the foramen magnum. In the upper right quadrant is an x-ray film showing an occipital fracture extending down to one side of the foramen magnum paralleling the lacquer cracks in the "stresscoat" preparations.

data corroborate these findings.<sup>8</sup> Fractures resulting from general deformations of the skull in general follow the strain paths seen in these experiments. In Figure 7 the cracks in the lacquer followed a blow at the bregma. The lines are seen to extend down toward the base of the skull on both sides. Below is seen the x-ray film of a clinical case with the fracture line extending from the vertex toward the base in a direction paralleling the strain patterns seen above. It should be noted that the fracture is more widely separated at the vertex. It is reasonable to assume that the area of impact causing this fracture was at the mid-line near the bregma. In Figure 8, results of a posteroparietal blow are shown to the left. The cracks in the lacquer are seen to extend downward and forward toward the temple. To the right are two x-ray films from clinical cases of head

injury. The upper x-ray film shows a depression in the posterior parietal region near the midline with fracture lines extending downward and forward on both sides. The point of impact in this case was undoubtedly at the posterioparietal region near the midline. In the lower x-ray film is seen a fracture line extending from the posterior parietal region downward and forward toward the temple. The fracture is more widely separated posteriorly, suggesting that the blow causing the fracture was applied in the posterioparietal region near the mid-line. In the above group of examples it is apparent that in certain cases one may estimate the location of the blow from the direction and path of the fracture lines. In Figure 9 are seen "stresscoat" preparations following midoccipital blows. The cracks in the lacquer extend downward toward the foramen magnum and then curve to bend laterally. In the upper right corner is a clinical case of head injury and this x-ray film shows a fracture line in the occipital region extending down toward the foramen magnum much in the manner that the cracks in the lacquer are seen to course. It should be emphasized that with high velocity energies there may be localized deformation with comminution, depression or perforation. It has also been mentioned previously that depending upon the size, shape and velocity of the injuring object, a certain direction may be given the strain paths.

Certain threshold values may be deduced from our studies of blows with varying energies. Whereas in the occipital region 8 inch-pounds of energy is sufficient to cause deformation patterns in the lacquer of the sensitivity used, in the midfrontal region 14 to 18 inch-pounds of energy are needed for deformations of similar magnitude. In the parietotemporal region, threshold values are obtained with 10 inch-pounds. It is therefore apparent that relatively minor blows may result in deformation of the skull with failure in certain regions. The ease with which deformations are produced about the foramen magnum and parietotemporal region may explain how in certain injuries linear fractures may obtain in these locations without loss of consciousness. A small amount of energy may be dissipated in causing deformation and failure of the skull. However, it may not be of sufficient magnitude to also result in adequate pressure waves in the cranial cavity to cause post-traumatic unconsciousness. A severe blow in the occipital region is associated with extensive deformation at the base of the skull, helping to cause intracranial pressure waves to add to the serious intracranial injury. Whereas a weak blow may cause a symptomless fracture line, a severe blow

may result in a serious state. It is clinically known that cases with fracture of the base may be seriously ill and yet there are instances in which the symptomatology is very slight.

In one skull, occipital blows were consistently associated with deformation patterns at the fronto-sphenoido-temporal junction on one or both sides. (Fig. 6.) From their position, they may well be called "contrecoup" deformations. "Contrecoup" fractures may thus be possible. Clinically, the association in some cases of "black eyes" with a fall resulting in an occipital blow may be explained by "contrecoup" deformations in the region of the origin of the temporalis muscles with postpalpebral bleeding.

### CONCLUSIONS

"Stresscoat" experiments have shown the pattern of maximum tensile strain due to blows on different parts of the skull. It has been found that there is greater tensile deformation at some distance from the point of impact. It has been shown that the deformations of the skull, due to blows of a given amount of energy in the occipital region, were far more severe than those due to blows at the forehead. The strain patterns indicate some difference in the behavior of different skulls, but the direction is the same. It has been shown that strain paths in the dry bone are essentially the same as in the living bone.

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## DISCUSSION

PRESIDENT GROVER C. PENBERTHY (Detroit): This very excellent presentation is deserving of discussion, as Dr. Gage has said. Unfortunately I missed a good part of the presentation, owing to the fact that an emergency meeting of the Council was called and it was necessary for me to attend.

Dr. Gurdjian has come as a guest speaker, at the invitation of one of our members, Dr. Charles G. Johnston, and I know that from what Dr. Johnston has told me relative to this work that Dr. Gurdjian has spent a good deal of time studying the mechanics of fractures of the skull. Many of you have seen Dr. Gurdjian's exhibit on head and skull injuries which has been outstanding each time he has presented his material. I am sure what he has presented to us carries with this presentation information that all of us have been more or less in doubt about, or had ideas about and here is the true picture of his extensive experimental and research activities in Detroit. We appreciate having Dr. Gurdjian go to this trouble in coming to this Association meeting and giving us this very excellent presentation of some of the factors pertaining to fractures of the skull.

# ANTEROLATERAL APPROACH IN BONE GRAFTING FOR UNUNITED FRACTURES OF TIBIA\*

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FOR a period of ten or twelve years starting immediately after World War I it had been customary for me to utilize a sliding inlay type of graft along the anterior flat surface of the tibia when grafting for non-union in this bone. Since 1932, however, a change in the approach has been made and instead of utilizing the above-named type of graft, we are now using an anterolateral sliding inlay type of graft. It is the technic of this procedure which will be covered in this presentation rather than a discussion of the pros and cons of bone grafting or a discussion of the indications, contraindications etc. of this procedure. Various types of technics have been described in carrying out tibial bone grafts including the use of many materials as fixing agents for bone grafts, these having been and being catgut, kangaroo tendon, silk, silver or steel wire, bone screws and in some instances even bone plates. Since 1922 nothing but Sherman type screws have been used in our clinic for the fixation of bone grafts and we feel that we were the first to utilize metal screws in the fixation of bone grafts.

There are several advantages in this technic and it is these which we wish to discuss somewhat in detail. These are:

1. *Site of Incision.* The incision is not made over the flat avascular unpadded portion of skin which lies immediately over the periosteum covering the flat anterior surface of the bone but rather is made lateral to the anterior ridge of the tibia over soft underlying fatty and muscular tissue thereby affording a more vascularized area of skin as the operative area. With this type of incision the periosteum is very little disturbed from the flat anterior portion of the tibia, it being mainly stripped off from the lateral side of the bone along with the muscles which are retracted laterally and posteriorly so as to afford exposure of the bone.

\* It is not the purpose of this paper to discuss the pros and cons of bone grafting but rather to present the technic of a procedure that has given the author and his associates excellent results in a large series of tibial bone grafts.

2. *Fixation.* As we utilize Sherman type stainless steel screws in fixation, this approach affords a more ideal locale for the screws, in that the heads do not lie immediately subcutaneously as is the case in the anterior approach but rather are buried deep laterally underneath the anterior tibial muscles which fall over completely covering the screws thereby creating no pressure points on the skin or the incision from within.

3. *Morticing and Impacting of the Graft.* In this approach a better bed is afforded for the graft and anchoring of the tip of the graft can more easily be carried out thereby preventing bowing and necessitating less metallic internal fixation.

#### TECHNIC

*Site of Incision.* When utilizing the anterior sliding graft regardless of the type of fixation or the size and type of graft, the incision of necessity had to be made immediately over the flat anterior surface of the tibia. This, you know, is the most avascular portion of the lower leg and is the place where the skin immediately overlies the periosteum of the bone as in this area there is but a very minimum amount of intervening subcutaneous fat. This anatomical arrangement has several disadvantages in that healing may be retarded because of sloughing of part of the suture line due to the poor blood supply and as it is the most exposed and least protected portion of the lower leg it is very easily susceptible to external trauma as well as to pressure from within.

In the anterolateral approach, however, as the incision is made  $\frac{1}{4}$  to  $\frac{3}{8}$  of an inch lateral to the anterior ridge of the tibia, these disadvantages do not present themselves. On the contrary, the skin is loose, has some subcutaneous fat and is overlying a soft muscular bed which is much more vascular than the area previously described so that there is a tendency for better healing, almost completely eliminating dangers of sloughing of part of the suture line and does completely eliminate the danger of having necrosis of part of the skin due to pressure from within. This incision can be of any desired length and in some of our cases has extended from the anterior tibial tubercle down to the level of the ankle joint proper. Skin flaps are then reflected laterally and after the skin edges have been carefully blocked the fascia and the periosteum is incised following which the muscles and periosteum are retracted laterally and posteriorly en masse thereby affording an excellent visualization of the entire lateral aspect of the tibia as high up and as far down as is desired.



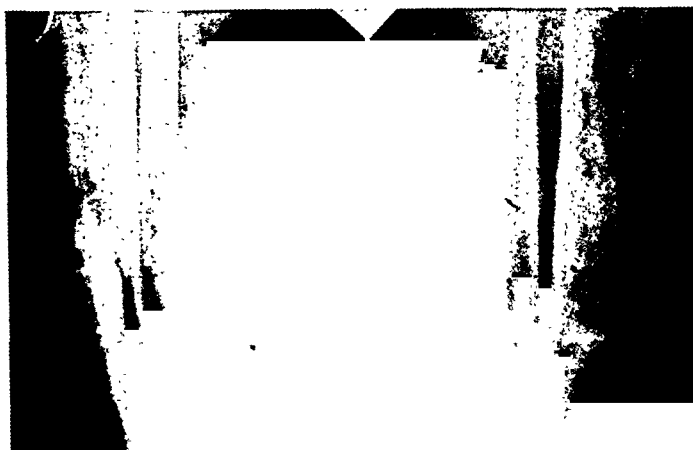


FIG. 1. Case 1. B. B., December 29, 1943, shows the non-union as it existed at time of admission to the hospital.

A short flap of periosteum is reflected medially just beyond the ridge of the tibia just to the point where the saw line for the graft is to be made. This incision also has another very complete and decided advantage, i.e. the operative area is in almost every case entirely independent of the site of the previously traumatized and scarred skin due either to a compound wound or to a surgical wound utilized in previous operative treatment of the original fracture. As most cases of non-union are compound rather than simple fractures and as the compound wound is most often along the anterior flat of the tibia, this incision made away from this area is in its entirety one going through fresh tissues that have not previously been traumatized or operated upon and in some cases involved in some infectious process whether it was of the soft tissues alone or of soft tissues and bone. Here one feels more sure that he is not stirring up some quiescent infection by going through the previously infected or traumatized scarred area.

In some cases there still exists or persists a small draining sinus or a small ulcerated area along the medial or anteromedial aspect of the tibia and it would be dangerous to attempt a bone graft using an anterior type of sliding graft with this present. On the other hand, by using our approach we do not go near these areas and we feel that a graft can safely be carried out on the bone with the small ulcerated area being cared for simultaneously with or after the bone graft has been carried out.

*Fixation.* As all our grafts are fixed with Sherman type screws, we shall not go into a discussion of the various other fixing agents used in bone grafting, our remarks being confined to screw fixing alone. In the anterior sliding tibial graft the screws which are used for fixation are inserted through the graft into the posterior portion of the tibia and as a result the heads come to lie immediately over the anterior flat tibial surface. This has several disadvantages in that they are immediately under the suture line thereby causing pressure from within on the suture line which itself is already in a poor area so far as tendency for healing by primary intention is concerned in that it has been made through the most avascular portion of the lower leg. Another undesirable feature is that the screw heads can readily be palpated from without through the skin which they immediately overlie and being thus situated are very susceptible to external trauma as well as external pressure, this being due to the lack of protective subcutaneous tissue in this area. In contrast to this, by using the lateral approach the screws are inserted from the lateral toward the medial aspect of the tibia being at a right angle to the anterior ridge of the tibia. In this locale they lie deep in the leg and are protected by the overlying anterior tibial muscles so that not only are the screw heads no longer palpable from without but they are so well covered by soft parts that all danger of pressure on the skin over the screw heads either from within or without is completely eliminated.

*Morticing and Impacting of the Graft.* This procedure, which is not a new one, has been used by us for the past 20 years. We utilize this morticing and impacting of the graft ends in all type of sliding grafts regardless of the bone which is being grafted. After the length and thickness of the graft has been determined and the saw cuts have been made, the distal and proximal ends of the grafts are then undercut so that the end of the graft itself is bevelled for a distance of about  $\frac{1}{4}$  to  $\frac{3}{4}$  of an inch at approximately a 30 to 45° angle. This along with the fact that the average graft is anywhere from  $\frac{1}{2}$  to  $\frac{3}{4}$  of an inch in width, makes for a graft which is heavy enough to permit good impaction, this morticing having been carried out at either end of the tibia. The procedure can be carried out with or without reversal of the bone grafts as each piece of bone, the one from the upper fragment as well as the one from the lower fragment, has at one end this prepared bevelled-like end and the bone proper at these ends has the underlying undercut arrangement which will permit for the pounding in and impacting of the graft thereby giving

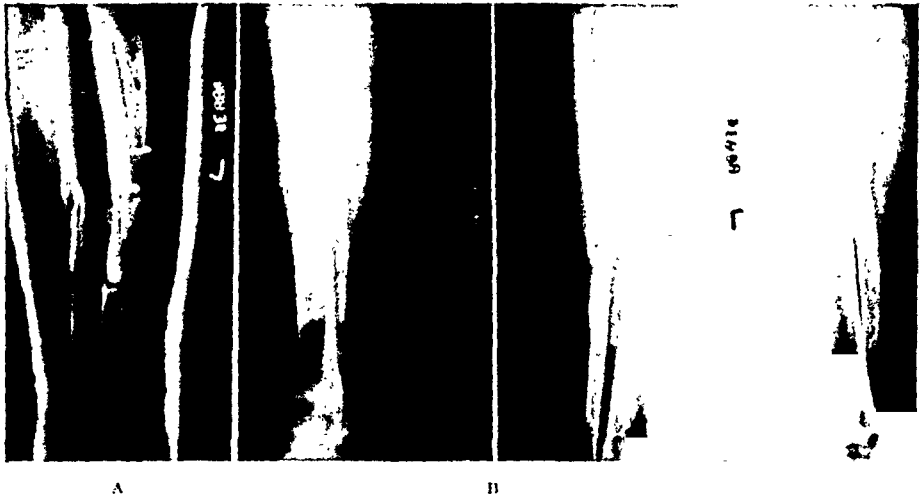


FIG. 2. A, February 29, 1944, taken postoperatively shows the graft held in place with a single screw but does not show a mark morticing of the graft at its lower end. This was not necessary here, however, as there was no pull from the muscles. B, May 6, 1944, shows the condition of the graft at the time that external fixation was removed.

excellent fixation at the one end, preventing bowing of the graft and necessitating much less metallic internal fixation. We attempt to fix these grafts with one screw holding the graft which transverses at the site of non-union and impacting either above or below the site of non-union, this most times is sufficient and no further screw fixation is necessary. In some instances when the muscle spasm is marked or where deformity has long persisted with angulation of the bones, and it is felt that too much strain will be placed upon the graft because of this long-existing muscle pull, two, three or sometimes even four screws may be used. This, however, is the exception rather than the rule, and is well illustrated in the case reports.

#### CASE REPORTS

CASE 1. B. B. age fifty-six, was admitted to the hospital February 27, 1944, with a history of having been involved in an automobile accident on April 1, 1943, sustaining a compound fracture of his left tibia and fibula for which he was treated in Youngstown, Ohio, until now. Examination at this time showed a non-union of the mid tibia with no open wounds on the skin. X-rays were taken and showed non-union near the mid portion of the left tibia with demineralization and disuse atrophy of the bone. Bone graft was advised. He was operated upon the following day and under pentothal anesthesia a sliding lateral bone graft with single

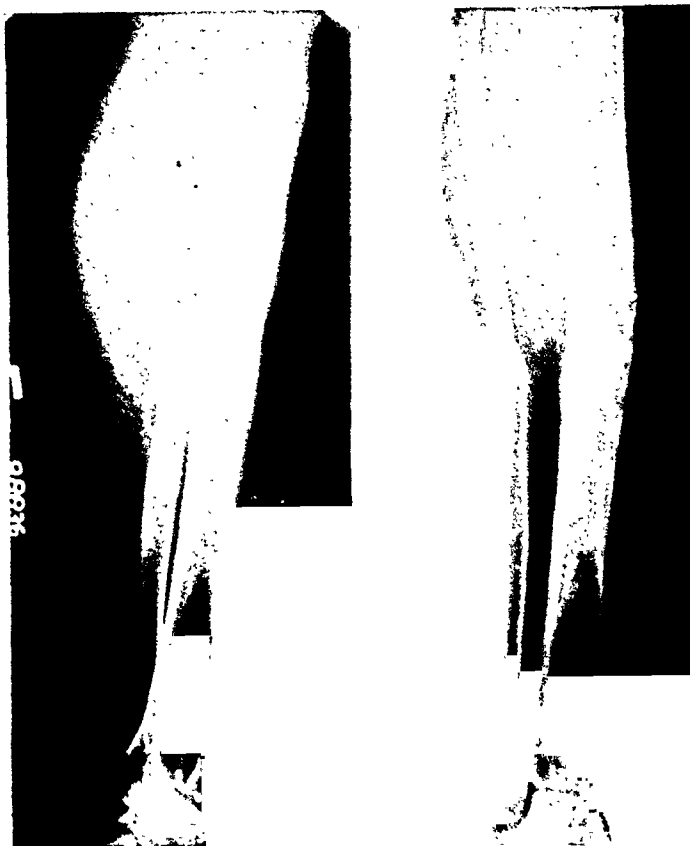


FIG. 3. March 1, 1946, shows the end result almost two years after the operation. It was noted that the graft had blended in nicely with the main tibial fragments and that the site of the non-union is readily noticeable. It is difficult to tell where the graft was placed unless one looks quite closely.

screw fixation was carried out. Wound healed per primam. Patient was made ambulatory on the tenth postoperative day and he was discharged from the hospital on the 15th postoperative day March 13, 1944.

He returned as an outpatient for further observation and check-up and Figure 1 shows his progress from the x-ray standpoint. Complete healing with solid union developed. Patient was permitted full weight bearing without external fixation at the end of fourteen weeks.

He was last seen on March 1, 1946, at which time he had no complaints, stated he had been doing his work completely and a final x-ray was taken which is included in Figure 1.

CASE II. A. G. age forty-four, was admitted to the hospital May 24, 1945, with a history of having been injured on April 11, 1944, while working in a steel mill in Youngstown, Ohio, sustaining a

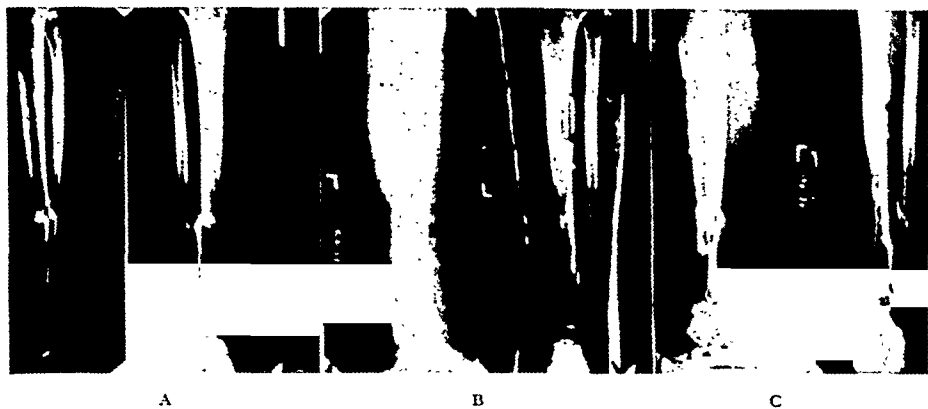


FIG. 4. Case 11. A. G. A, May 25, 1945, preoperatively shows a non-union of the tibia with marked demineralization of the bone. B, shows the sliding lateral graft with single screw fixation and in the anteroposterior view shows very clearly the morticing and impaction of the lower end of the graft. The upper smaller graft is held in place without fixation, June 9, 1945. C, December 1, 1945, taken six months postoperatively shows excellent healing with blending of the graft into the major tibial fragments and obliteration of the site of non-union.

compound fracture of his left tibia and fibula in the region of the middle and lower thirds. A closed reduction was carried out and progress was satisfactory for a while but around New Year's day of this year a draining sinus developed at the site of the compound fracture. This discharge cleared up in a few weeks but patient's leg was still painful, he was unable to bear his full weight and was sent here for examination.

Examination at this time showed the left lower leg to be atrophied and showed no evidence of any draining sinuses. There was a definite non-union demonstrable clinically at the fracture site in the lower third of the leg and x-rays showed a non-union of the tibia with complete healing in the fibula. There was no deformity at the fracture site but no definite osseous union could be demonstrated. There was also a marked demineralization of the bones of the leg and foot with disuse atrophy. The foot and ankle were manipulated after admission. Patient was encouraged to walk around on the limb to increase the blood supply of the part and on June 8, 1945, fifteen days after admission, the condition of the leg was thought to be such that grafting could safely be done. A lateral sliding bone graft with single screw fixation was carried out. (Fig. 2.) Postoperative course was uneventful, wound healed per primam and the patient was made ambulatory with the aid of crutches on the tenth postoperative day and he was discharged on the twentieth postoperative day June 28, 1945.



FIG. 5. Case III. J. P. A, August 1, 1945. preoperative plate shows non-union, angulation and overriding of the fragments at the fracture site. B, immediate postoperative picture, shows nicely the morticing of the graft and shows three-screw fixation which was necessary to overcome the marked muscle pull on the graft. The upper graft, however, needed no fixation. C, December 10, 1945, shows healing at the end of two months. D, June 20, 1946, shows condition of the leg ten months after operation and after the screws have been removed. Note how the graft blends in with the major tibial fragment above as well as the minor tibial fragment below. There is some absorption of the tibia at the fracture site but this has since filled in.

He returned as an outpatient for further observation. The graft healed nicely and at the end of fourteen weeks all external fixation was removed and the patient was permitted weight bearing.

When last seen one year after the operation the leg was solidly healed. Patient had been working at his regular duties since the sixth postoperative month and the last x-ray taken on December 1,

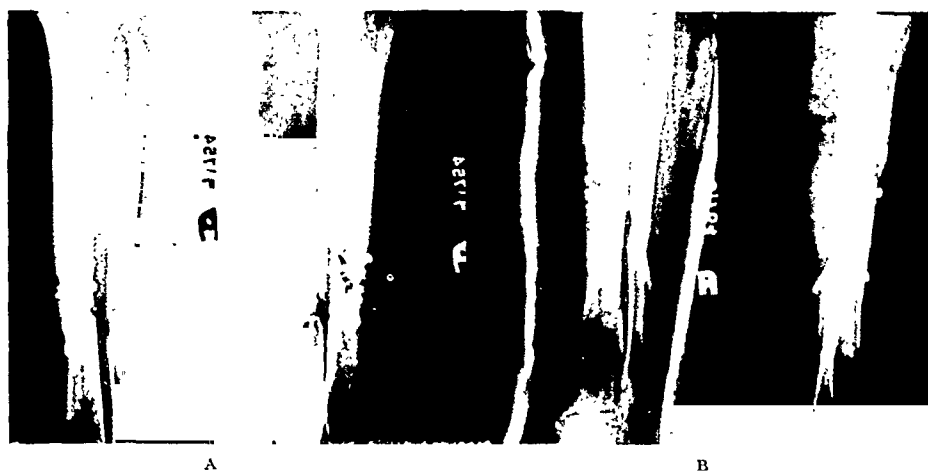


FIG. 6. Case IV. F. P. A, December 28, 1943, shows the non-union following open reduction with transfixation screws as well as with plate fixation. This was five months after the fracture was sustained. B, May 18, 1944, shows the graft which was held in place with two screws blending in with the major tibial fragments and obliterating the site of non-union.

1945, showed an excellent osseous organization between the graft and the main bone fragments.

CASE III. J. P. age thirty-six, was admitted to the hospital July 31, 1945 with a history of having sustained a compound fracture of his left tibia and fibula in Weston, W. V. in August, 1944. He was treated by closed reduction at the time of his original injury, the cast not being removed until six weeks later. At that time as there was no evidence of bony healing, an open reduction with plate fixation was carried out. Healing did not take place satisfactorily. Some drainage developed at the site of the compound wound and several months later the plate and screws were removed. His progress was not satisfactory, the draining sinus persisting at the site of the compound wound and the patient developing a marked angulation with complete medial displacement of the proximal ends of the distal fragments of the tibia and fibula.

X-ray was taken on admission and showed the ununited fracture as well as the old screw holes in the tibia and some irregularity at the ends of the tibial fragments but no definite evidence of infection was noted. There was also a marked demineralization of the bones with disuse atrophy.

The draining area at the site of the compound wound was treated locally and in time healed. Patient's foot and ankle were manipulated on several occasions. Check x-rays immediately postoperatively showed that the distal screw had pulled out of the graft permitting

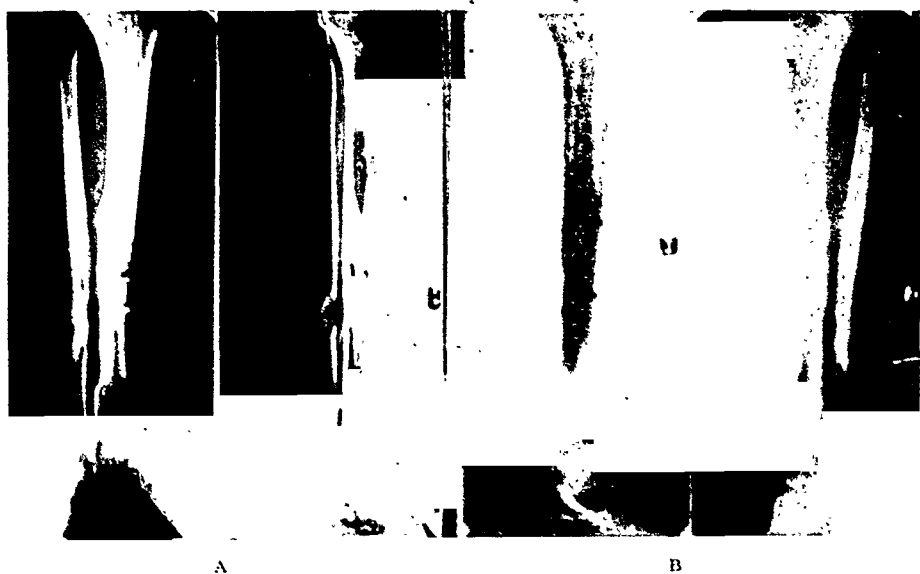


FIG. 7. A, June 29, 1944, shows healing of the graft months after grafting. B, June 13, 1946, over two years after the grafting was done, shows the end results with complete blending of the graft into the major fragments and with the two transfixion screws barely noticeable.

the graft to slip. The wound was allowed to heal and on August 28, 1945 the lower end of the wound was reopened, the graft was slid into place and a new screw was inserted holding the graft in place and correcting all angulation. The wound again healed per primam, the patient was made ambulatory and was discharged from the hospital on September 16, 1945.

He returned as an outpatient for further observation and healing took place slowly but satisfactorily and at the end of eighteen weeks was bearing weight with the aid of crutches but without external support to the lower leg.

At the end of six months he was bearing weight completely but on April 12, 1946, patient returned and as a draining sinus was present at this time he was readmitted to the hospital. The sinus was at the site of the compound wound. X-rays at this time showed absorption around the middle screw and some destruction of the major tibial fragments at the site of nonunion. This was cleaned up locally and operation was carried out April 24, 1946, at which time all three screws were removed with saucerization of the major tibial fragments at the site of non-union. A small sequestrum was also encountered and removed. The wound was permitted to granulate from below and when healthy granulations were present the ulcerated area was grafted, this procedure being carried out on June 14, 1946. Healing took place satisfactorily and completely. Patient





FIG. 8A.



FIG. 8B.

FIG. 8. Case v. G. B. A, February 6, 1945, fourteen weeks after the original injury shows a non-union which developed at the fracture site. B, February 9, 1945, shows immediate postoperative film with bevelling and morticing of the graft clearly demonstrable and shows two-screw fixation, this being necessary because of the muscle pull causing bowing in the preoperative film. The upper graft needed no fixation. C, June 13, 1946, sixteen months after the operation, shows complete healing of the graft with blending of the graft into the tibial fragments and with some scarring of the bone. Film, however, is not too clear.

was discharged from the hospital July 9, 1946, completely healed and instructed to report as an outpatient for further observation.

The final x-rays taken on June 20, 1946, showed excellent healing. Patient has a good strong leg. The soft tissues are all completely healed and strong. He is progressing satisfactorily.

CASE IV. F. P. age forty-nine, was admitted to the hospital on July 29, 1943, with a compound comminuted fracture of the right

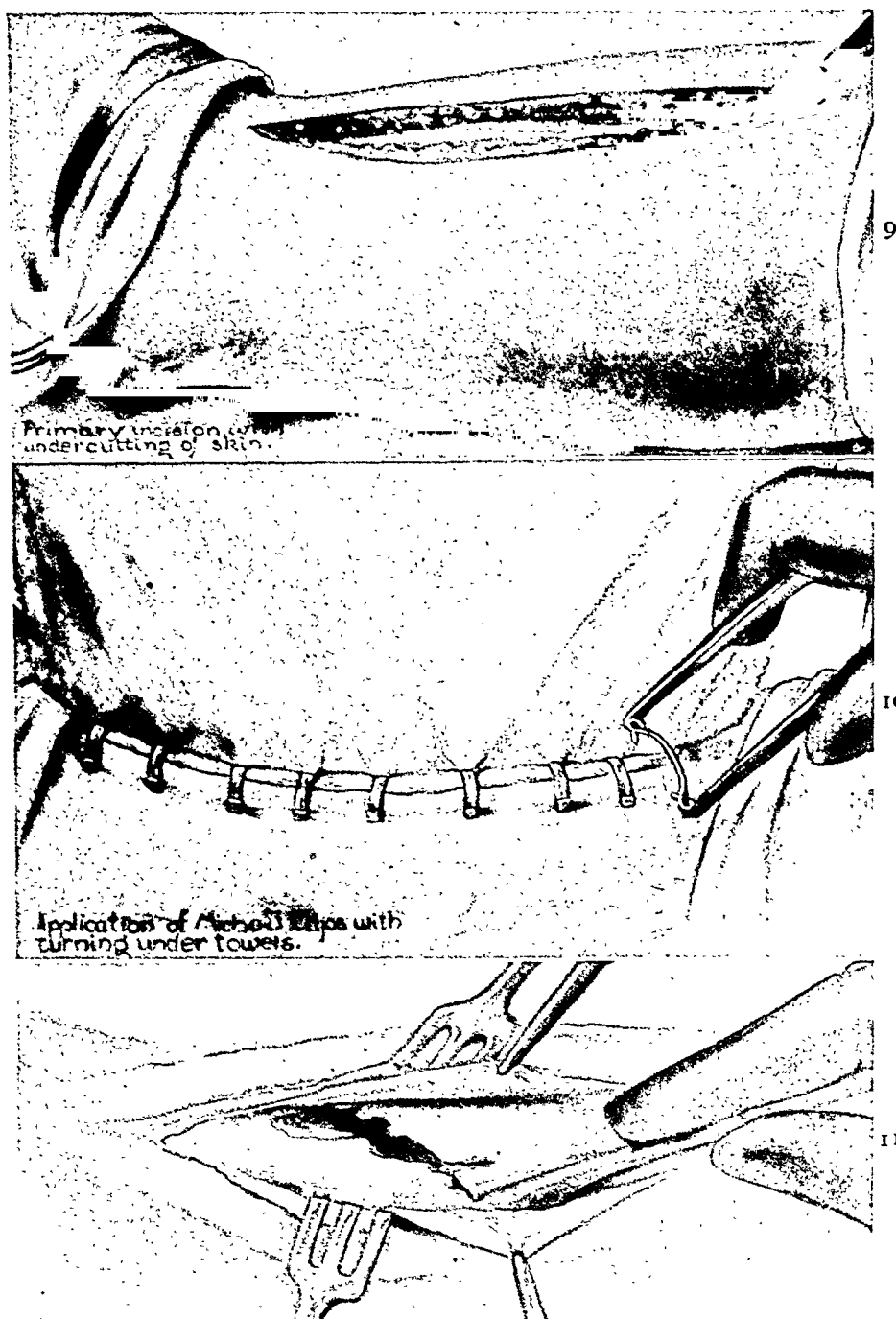


FIG. 9. Drawing shows site of incision. It is noted that the incision is approximately  $\frac{1}{2}$  inch lateral to the ridge of the tibia and is made long enough to afford adequate exposure.

FIG. 10. Shows the wound edges being blocked with the use of Michele clips on sterile towels.

FIG. 11. Shows exposure of the fracture site with subperiosteal stripping of the periosteum and anterior tibial muscles laterally and posteriorly *en masse*. Clamps are on the periosteum. The fracture site with the non-union are clearly visible.

tibia and fibula, this having been sustained several hours prior to his admission when he was struck across his leg with a large piece of steel while working in the mill. Examination on admission showed a ragged dirty compound wound near the junction of the middle and lower third of the right leg with the bone fragment protruding thru the wound. Under pentothal anesthesia a debridement of the wound was carried out along with a closed reduction of the fracture. Check x-rays showed a satisfactory reduction of the fracture. The wound healed per primam.

The bone, however, did not show any signs of healing and for this reason the patient's hospital stay was prolonged, he being here until September 21, 1943. At this time he was discharged on crutches with a walking iron and cast to his leg and instructed to bear weight so as to stimulate healing.

He returned as an outpatient periodically but later x-rays again showed that no bony healing had taken place. The patient was readmitted to the hospital on October 28, 1943, our intentions at this time being to carry out a bone graft. He was operated on November 5, 1943, but at that time instead of grafting, the fractured ends of the tibia were freshened and an open reduction with plate fixation was carried out. This procedure was carried out as the appearance of the bones was such at the time of operation that it would lead one to believe that healing, although delayed, would take place. Again the postoperative course in the hospital was uneventful but healing was slow so far as the bone was concerned, his hospital stay being prolonged until January 4, 1944. At this time he was discharged again with a solid cast and a walking iron and instructed to bear weight.

He continued to return as an outpatient and was observed until March 14, 1944, with non-union still being present. He was readmitted to the hospital for a bone graft. This was carried out the following morning under pentothal anesthesia and a sliding graft with two-screw fixation performed. The wound again healed per primam and as in the previous two admissions bony union again was slow. His hospital stay was prolonged until June of 1944, at which time there was enough osseous healing to permit weight bearing. He returned as an outpatient and twenty-two weeks after his operation there was enough bony union to permit full weight bearing without the aid of crutches.

He was last seen several weeks ago at which time the leg was completely healed, union was solid, patient had no complaints and a satisfactory result was obtained.

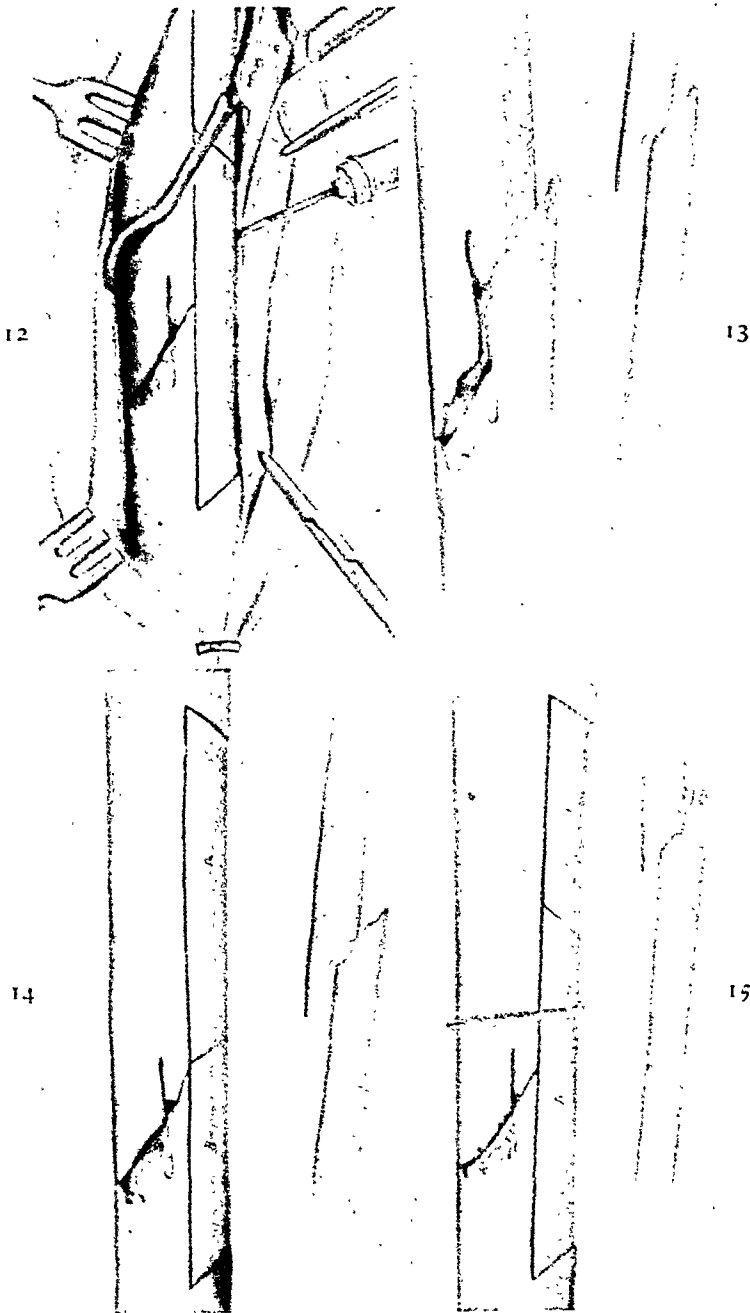


FIG. 12. Shows the graft in place, being held there tightly by means of a Berg clamp while the hole for the Sherman screw is drilled.

FIG. 13. Schematic sketch showing fracture with non-union indicating preoperative condition.

FIG. 14. Schematic sketch showing reduction of fracture, cleaning out of site on non-union, and cut graft with morticed edges.

FIG. 15. Shows graft in position, being held by a single Sherman screw. The lower end is tightly held in place by the morticing effect. Note that the small graft (b) is in place without any external fixation.

CASE V. G. B. age twenty-five, was admitted to the hospital January 23, 1944, with a history of having sustained a compound fracture of his right tibia and fibula along with a fracture of his skull, a severe brain concussion and other soft tissue injuries in an automobile accident on December 25, 1943. He was in a Rochester, Pa. hospital with these injuries until his transfer here.

Examination at the time of admission to the hospital showed the right lower leg to be in a solid plaster cast and after removal of the cast examination showed marked deformity of the leg with complete healing of the compound wound. The patient was still mentally confused at this time. X-ray examination showed complete overriding with both the tibia and fibula near the mid shaft with lateral displacement of the major distal tibial and fibular fragments along with comminution at the fracture site. He was operated upon under spinal and pentothal anesthesia on January 26, 1944 with difficulty. A complete reduction of the fracture was obtained, this being fixed with a Sherman plate. The fibula was also reduced through a separate incision and approximated end to end. Healing of the wounds took place by primary intention and patient was discharged from the hospital on March 9, 1944 with lateral plaster splints applied supportively.

He returned as an outpatient for further observation on May 14th was readmitted to the hospital so that the bone plate which was causing some pain and which showed some absorption around one of the screws could be removed. This was carried out the following day and the patient was discharged from the hospital on May 23rd.

He continued as an outpatient and as healing did not satisfactorily take place and a non-union developed, bone graft was advised. He delayed this for two months before being readmitted to the hospital on February 5, 1945, this being fifteen months after the initial injury. He was operated on February 7th when under pentothal anesthesia a lateral sliding bone graft with two Sherman screws for fixation was carried out. Postoperative course was uneventful, wound healed per primam and the patient was discharged from the hospital on March 17th, with his leg in a cast and with instructions to continue as an outpatient for further observation.

He returned as such and sixteen weeks after the grafting was carried out a solid bony union had taken place which permitted the patient full weight bearing without external support. When last seen one month ago patient was completely healed, was back at work as an engineer and had no complaints whatsoever.

## SUMMARY

We have just presented a discussion of the technic used in carrying out an inlay sliding tibial bone graft through an antero-lateral approach. The advantages of this approach over the old anterior approach have been discussed in detail. This discussion included the location of the incision and the reasons for its being so placed, the method of fixation with its advantages, and the utilization of morticing and impacting of the graft to further aid in fixation.

We have summarized five cases in which this procedure was used, various methods of fixation being employed. The accompanying pictures show the progress of these cases.

## DISCUSSION

JAMES SPENCER SPEED (Memphis): I have enjoyed this presentation by Dr. Wagner very much. He has shown us from a practical standpoint the advantages of placing grafts or plates on the lateral surface of the tibia rather than on the anterior medial surface.

This has been pointed out to have many obvious advantages, particularly the avoidance of adhered scars on the anterior medial surface of the tibia. These frequently require extensive plastic work before a bone graft can be done if you contemplate either the dual graft on both sides or a single inlay or inlay graft on the medial side.

It has an added advantage in that the compressive action of the muscles against the lateral surface of the tibia maintains the position of the graft frequently without any type of fixation. I prefer fixation if it seems advisable, but in cases where a flare-up of infection may be anticipated the introduction of screws adds to the risks, one can apply these grafts either as an inlay or onlay, whichever one prefers, along the lateral surface. In many cases where there is an open sinus on the medial surface of the tibia, the graft may be applied, without preliminary treatment of this area, by approach just lateral to the crest of the tibia, thus avoiding the area of infection. This procedure has been employed by us in a number of cases without infection in the operative site.

I was very much interested in seeing some of the plates that were put on in the presence of non-union plus infection, and I think many of us perhaps would criticize this procedure as such, but it has a very definite place. In Dr. Wagner's cases he utilized the application of a plate during the period of infection, to improve his position and maintain position in preparation or anticipation of a subsequent graft. This is a very valuable thing to do in many cases, because it eliminates the necessity for extensive trauma at the time of the bone graft.

I have had a number of cases in which union has occurred in spite of

infection, following the use of a plate as a preliminary measure to maintain position for subsequent graft. The lateral approach, the lateral placing of the graft, I think, is ideal for any type of case, even simple non-unions, and we have used it almost uniformly in our single grafts. I much prefer the use of the lateral placing of the graft to medial placing for the purposes outlined by Dr. Wagner. It should be utilized more.

RALPH G. CAROTHERS (Cincinnati): I, too, have enjoyed this paper very much and I should like to bring up just two points:

One is the lateral approach, which is just good, plain, common sense. I do not think there is anything more to be said about it. The other is the subject of a plate in a dirty case. We have been in the habit of using plates or screws for compound fractures when they are fresh, even though we know they will have to be taken out later. There is the advantage of maintaining immobilization and lessening the amount of scar.

One very dramatic case occurred two months ago in a man who had tabes, who had phlebitis in the leg and an ulcer as big as a plate which was filthy. It was through that ulcer that he compounded the leg. I thought the best surgery would be to make a transverse incision at his neck but I might have been in trouble with the police if I had done that, so I plated the tibia and gave him penicillin and strangely enough, the whole thing healed, and he is still wearing his plate. The fracture healed and his condition progressed satisfactorily.

HOMER STRYKER (Kalamazoo): I just want to add a point or two.

We have used this almost routinely but many times we use a graft from the other leg. We find it is not necessary to make nearly as much of an exposure. You do not have to remove the periosteum and scar from the anterior at all but just make a channel, chipping off a little of the bone with the periosteum and at the lower end inserting it into the bone as the flare goes out. Then perhaps a screw or two in the upper end is all that is required.

Another thing: In these cases of non-union, in which the fibula has united and it is necessary to do an osteotomy on the fibula, let the fibula still be attached to the soft tissue on the lateral side, with the periosteum removed on the side toward the tibia, letting it go over against the graft. This gives an additional fibular graft which already has its blood supply.

In children with loss of bone substance through compound fractures or primary loss of bone substance, we put a pin through the upper end of the tibia and one through the lower end, or perhaps the os calcis, until the fibula is united enough to maintain the length. Later bridge that gap with a massive bone graft such as has been shown previously in the meeting.

J. HUBER WAGNER (closing): I just presented the method and procedure here and did not want to go into the grafts as I did. I think this method readily does away with the use of the fibula as a graft.

Concerning going over to the other leg, that is another ideal of this. There is always enough bone left in any fracture that you can graft in the

tibia, whether it be above or below. You do not have to go into the other side. That is the privilege you have here. You can take as much as half of the entire portion of the tibia and transpose it. It lessens operative shock and the good leg is not taking a chance.

I think the time for the use of fibula grafts has passed. I do not want to stir up any discussion, but thank you very much for discussing my paper.



# TRAUMA IN MALIGNANT TUMORS OF BONE

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A REVIEW of the voluminous literature dealing with the question of injury as a causative factor in the development of malignant tumors in general and of bone tumors in particular leaves the reader convinced that from the mass of conflicting opinions and theories expressed it is difficult if not almost impossible to reach an unbiased conclusion.

We are not concerned here with any of the so-called chronic irritations of occupation, such as chimney sweep cancer or mule spinner's cancer. We are interested only in the relationship of direct trauma as a theoretical causal factor in the development of sarcoma of the musculoskeletal system.

The question of whether a malignant bone tumor which developed or was first recognized after an injury to the part was caused by said injury, is one that has been argued *pro* and *con* for many years. While in earlier times this was a matter merely of academic interest, with the advent of Workmen's Compensation legislation and liability insurance the whole question has taken on great medicolegal importance.

Unquestionably the majority of those of the medical profession who conceded a causal relationship of injury to bone sarcoma have been clinicians while the opponents of this view have, almost without exception, been pathologists. The trend of opinion in recent years has been to doubt the importance of a single trauma; those who still accept it are in the minority. After many years of experience in the field of bone tumors, the author must confess to an uncertainty of opinion and to a feeling that the final answer has not as yet been provided. He does not hold that a single injury cannot ever be a factor of etiologic significance. He feels that a study of the histories of a large group of cases of bone sarcoma leaves one with the inescapable impression that in a high percentage of cases, 50 per cent in some types of tumors, recent local injury antedated the demonstrable appearance of the tumor. Does this have significance—was it merely a coincidence—or did the injury call the patient's attention to a pre-existing tumor, i. e., *traumatic determination* (Ewing)?

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Obviously it is human nature for the layman to ascribe a malignant tumor to an antecedent local injury even though there may be no material gain or selfish interest at stake. On the other hand, everyone during the course of life sustains injuries some of which are of even greater severity than those cited as being responsible for a bone tumor. Therefore, injury cannot be regarded as the *sole* causative factor. The exceeding rarity of late sarcomatous development following so serious an injury as a major long bone fracture is an argument that has often been advanced by the opponents of the *traumatic* theory. We know of no case of bone sarcoma in the Memorial Hospital records in which there is clear evidence that it originated at the site of a simple fracture.

In 1907, at the French Congress of Surgeons, Segond outlined certain conditions which he felt must be fulfilled for the establishment of a causal relationship between an antecedent local injury and a subsequently developing malignant tumor. They imply the following: (1) That there was a verified trauma, (2) that it was of sufficient severity, (3) that reasonable evidence existed of the integrity of the part prior to the injury, (4) that the site of the injury corresponded to that of the tumor, (5) that the tumor appeared at a date not too remote from the time of the accident to be reasonably associated with it, and (6) that the diagnosis was confirmed by clinical, roentgenographic and whenever possible, microscopic examination.

These criteria have been widely accepted both in Europe and in America as a basis for adjudication of disputed claims. In actual practice, however, they are very seldom verified and the fact that they exist is an incentive to a clever lawyer or doctor who is financially interested in the case to "trump up" stories and manufacture evidence to conform to these criteria. Commenting specifically on criterium 2, *i.e.*, sufficient severity of the trauma, this, we regard as most vague. Apparently no one knows how severe or trivial an injury must be to be regarded as the theoretical cause of a cancer. One almost has to adopt as a working hypothetical possibility the theory that any trauma of any sort and of any degree of severity may cause any sort of cancer in any location. In other words, there seems no clear way to quantitate the amount of trauma that is necessary to cause cancer. It is worthy of note that in the majority of claims filed in the Compensation Courts of New York the injury to which the tumor was ascribed has been trivial; seldom has there been any evidence of a major alteration of the part concerned.

The author feels that in many medicolegal cases in the past, injury as a determining factor has been over-emphasized and that decisions have been rendered on a flimsy structure of scientific evidence. It is believed that the system in vogue at present whereby medical expert testimony is given, is shocking in several particulars and is rendered less valuable by the undeniable fact that the expert would not have been called by his side had his views not been known in advance and his opinion anticipated as being favorable. Until the present set-up is revised and all experts are called, employed and recompensed by the Court rather than by the plaintiff or the defendant, real experts will shun medicolegal cases and the evils of the present day will continue unabated.

In the interest of fair play, to assure a complete clinical record, to avoid important blanks in the sequence of a given history, it should be the inviolate rule that whoever takes the initial history of a patient with a suspected sarcoma should set forth in the records certain pertinent facts. First of all he should ask the patient to what he attributes his tumor and if the latter describes an injury, he should then be asked whether the cause has been suggested to him by others. Proceeding with the history it should contain the following facts: (1) Date of injury, (2) nature and mechanism of injury, (3) site of injury, (4) subsequent manifestations of injury, e.g., ecchymosis, swelling, tenderness, disability, (5) period following injury in which these symptoms persisted, and (6) interval between subsidence of symptoms and signs of injury and first recognition of symptoms or signs of tumor.

In addition a complete clinical record should include roentgenograms of the part concerned taken as soon as possible after the injury as well as others taken subsequently.

*Aggravation.* The provisions of the Workmen's Compensation laws of many states presume that an injury is compensable which can be construed as having aggravated a pre-existing malignant tumor. Therefore, claims of aggravation are often made, and this, introduces a much more controversial issue. From what is known of the dissemination of malignant cells it is probable that direct trauma to the primary lesion might be conducive to metastasis. However, the only experimental evidence on single trauma in tumors of known dissemination rate fails to support this view point, and the fact remains that malignant tumors do metastasize with or without local trauma. It has seemed to the author that in a given case one would have to show that the clinical course

of the disease had been adversely affected by the trauma, *i e.*, that it ran a much more rapid course than the average untraumatized case. Even then one must realize that there is a great natural variation in the rapidity of spread and total duration of malignant tumors. It would appear therefore that if a sarcoma were accepted as having existed prior to injury the circumstances of its course thereafter would have to be exceptional before one could justifiably assume aggravation.

Decisions in these accident cases that are adverse to the workman or to the injured plaintiff frequently entail severe hardship to the individual or his family. In an effort to avoid any possible injustice to the injured party the doctor is apt to let his sympathies color the medical testimony which he offers. This motive seems also to influence the referee, the jury and sometimes even the judge. Yet as Steward has pointed out, this is no excuse for making awards in the face of incompetent evidence or of using "supposedly scientific medicine to further his Notion of proper social behavior."

Stewart illustrates the faulty reasoning of the "supposed expert" as follows:

"The same surgeon who will do all sorts of orthopedic jobs involving chiseling into bone or insertion of such objects as ice tongs or pins or screws may testify that a blow which has left no real signs has caused an osteogenic sarcoma, although he never thinks his surgery will do so nor has he ever warned a patient with the severest form of bone trauma—a fracture—to be on the lookout for a possible sarcoma." Such arguments bear much weight and are hard to refute.

There are certain bone processes and benign lesions in which the role of trauma seems more difficult to deny. Of these the most conspicuous is benign giant cell tumor of bone. Considerable authoritative opinion upholds the theory that this tumor is commonly caused by the effects of trauma. Many patients with giant cell tumor have been awarded compensation, and we believe rightly so. On the other hand, it should be pointed out that pathologists who have had considerable experience in bone neoplasms are unconvinced that even in giant cell tumor trauma is an important etiologic factor.

On rare occasions we find an osteogenic sarcoma associated with a previously incurred ossifying hematoma and in such instances it is difficult to dissociate the origin of the sarcoma from the injury which caused the ossifying hematoma, and yet the

periosteal hemorrhages of scurvy are apparently never the precursor of sarcoma.

Certain cases of osteochondroma or chondromyxoma have been studied where injury has seemed to initiate a change in the type of tumor to that of chondrosarcoma and occasionally unsuccessful extirpation of such a benign tumor has been followed by recurrence and a transition to fully malignant chondrosarcoma.

Therefore we believe that injury may play an important part in such transition and as a preventive measure we advocate removal of these tumors when they occur in a location which renders them liable to external injury. It must be admitted however that on a number of occasions we have seen such malignant degeneration occur in cases of osteochondroma in which there was no history of injury.

To summarize briefly, it would seem that the rôle of single injury in the development of bone sarcoma has been overemphasized. A critical evaluation of each case and a decision based upon a scientific appraisal of all the known facts has not been the rule. Little support of the *traumatic* theory has been afforded by the pathologist; no laboratory experience seems to favor it. Considering the universality of injuries on a par with those alleged to be the cause of sarcoma of bone it is difficult to explain why so few of them are followed by the development of sarcoma.

So-called expert testimony on matters involving the alleged relationship of injury to malignant disease is not at present likely to appeal to the disinterested observer as worthy of credence; it is colored by the profit motive. Until qualified authorities are summoned by the court and not by the plaintiff or the insurance carrier to pass upon the merits of each case in a judicial and scientific manner, medical expert testimony will continue to be of doubtful value and will not enhance the doctor's reputation.

# SOME OBSERVATIONS ON PENETRATING WOUNDS OF THE HEART

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IT is difficult to justify a paper on penetrating wounds of the heart. The condition is fortunately rare in civilian practice and as a rule rapidly fatal. Death is usually the result of a pistol wound tearing large holes into the cardiac cavities with massive and rapidly fatal hemorrhage. The smaller wounds of the heart are mostly from knife stabs and are accompanied by a small opening in the pericardial sac. In this type of wound, hemorrhage from the heart cannot escape through the small pericardial opening and squeezes the heart into immobility. Most of the recoveries reported from heart wounds are of the stab wound variety in which the surgeon has been able to decompress the heart before intrapericardial pressure kills the patient.

In war wounds, it is possible to receive penetrating wounds of the heart in which the patient will survive for an astounding length of time. The surgical results in these patients are satisfactory providing there are not other complications. During my service with a Canadian Field Surgical Unit in the European Theatre of war I encountered four such wounds of the heart. One of these patients had an uncomplicated wound and recovered. The other three were complicated by other wounds. Two of these patients died and one recovered. I hope to justify this paper by describing the conditions necessary for long term survival in heart wounds and to report the difficulties in diagnosis and operation.

In war, high explosives cause about seventy per cent of the wounds encountered. The fragmentation of shells and mortar bombs will produce missiles of varying sizes traveling at exceedingly high velocity. Minute bits of metal traveling at this high velocity can spatter against the sternum or a rib and then penetrate the heart. These bits of metal will tear large holes in the pericardial and pleural sacs but for some peculiar reason make only small holes in the heart musculature. The combination of a large communication between the pericardial sac and some other body cavity with relatively small wounds in the heart is necessary for long term survival of the pa-

tient. The large hole in the pericardium allows the blood to escape and prevents squeezing of the heart.

From direct observation in all four patients, the small hole penetrating into the heart cavities does not bleed as freely as was formerly thought. Bleeding occurs only in systole and consists of small spurts of blood. The amount lost with each heart contraction is astonishingly small. The largest penetrating wound seen was about one third of an inch in diameter. The blood from this wound rose about one inch in the air during systole and each spurt lost approximately one teaspoonful of blood. It is impossible to state how large a cardiac wound would have to occur before continuous and rapidly fatal hemorrhage follows. It is certainly true, however, that wounds up to one-third of an inch in diameter, whether in ventricle or auricle, do not bleed furiously or continuously, but only in small spurts during systole.

In none of these cases was the diagnosis of a penetrating wound of the heart made by clinical examination. The perforation was suspected only by the anatomical location of the entrance wound. Careful auscultation did not reveal any abnormal sounds. The clinical picture was consistently one of profound shock usually accompanied by dyspnea. Since the left pleural cavity contained a large quantity of blood and air in three of the cases this was not surprising.

Diagnosis was made by suspecting and exploring. In the suspected cases careful wound toilet was performed, preferably under local anaesthetic. Through the wound a finger exploration of the pericardial sac was made. When a hole was found in the pericardium the patient was switched to pressure anaesthesia and a rib resected over the site of the pericardial opening. All the blood in the sac was sucked out and the opening watched. If the pericardial sac again filled with blood the diagnosis of a penetrating wound of the heart was made.

The surgical approach to the heart was, in all four patients, through a trapdoor incision over the third, fourth and fifth ribs on the left side. These ribs were resected subperiosteally, about a half an inch from the sternum and again about three inches laterally. The intercostal muscles were cut, and the flap turned back. The heart wounds were all easily located and sutured with interrupted silk. The pericardium was left open. In all cases the incision was closed by first bringing the intercostal muscles together and turning down a flap from the left pectoralis major muscle. This rendered

the wound airtight. The chest was then aspirated and the patient put on the usual resuscitative measures.

#### CASE REPORTS

CASE I. H. C. was thirty-two years of age. He had multiple mortar wounds. The time of wounding was 2:00 P.M. and time of operation was 11:30 P.M. Three small wounds were seen in the front of the chest. One of these wounds was in the left fourth interspace one inch from sternum. Patient was in severe shock. Blood pressure 70 systolic, 40 diastolic. Apex beat was not displaced. The patient was quite dyspneic and cyanotic. Thoracentesis obtained 1200 cc. of blood and 400 cc. of air. Wound in the fourth interspace was trimmed and wound toilet carried out under local anesthesia. Finger exploration demonstrated a large hole in the pericardial sac. Pressure anesthesia was given and the fourth rib resected. The pericardial sac was found full of blood and sucked dry. Observation showed that the sac continued to fill with blood.

The pericardium was exposed through the trapdoor incision. The opening in pericardium was enlarged and two wounds were found in the heart muscles. The holes were about one inch apart, four mm. in diameter, and presumably one lay over the right ventricle and the other over the left ventricle. From both wounds a stream of blood spurted with each contraction of the heart. No leakage occurred at any other phase of the heart beat. The wounds were sutured with interrupted silk and hemorrhage easily controlled. The pericardial sac was left wide open and the wound closed without drainage. The chest was aspirated and 600 cc. of air and blood removed.

Condition was only fair after the operation but oxygen and transfusions improved the patient considerably. The following morning the chest was again needled and a dry tap obtained. This patient continued to improve and was evacuated on the eighth day.

CASE II. M. H. was a fifty year old German prisoner, with a single shell wound. The time of wounding was 6 P.M. and time of operation 12:30 A.M. This patient was in exceedingly poor condition. Blood pressure was 90 systolic and 60 diastolic. Then there was a single wound in fourth interspace about one inch from the sternum which was sucking air. The patient was very frightened and hysterical. In spite of his condition and language difficulties it was quite obvious that he was suffering severe pain in his left shoulder area. He would grab and rub the shoulder and scream at the top of his voice. Morphine had no effect on him and he did not improve with transfusions. We were forced to operate in order to close the sucking wound. Local anesthesia was impossible. Under pressure anesthesia a hasty debridement of the wound was performed followed by finger exploration of the pericardial sac. A large hole was found in the sac. The fourth rib was resected and the sac found full of blood. It was sucked dry but soon refilled.



The pericardium was exposed. The tear in the sac was enlarged and it was easily seen that two wounds in the heart were present. The first wound had divided the descending branch of the left coronary artery and had penetrated the left ventricle. The second was apparently the wound of exit and was situated on the upper lateral side of the heart in the left auricular area. The torn coronary artery was not bleeding. Blood spurted from the hole in the ventricle and auricle on systole but not at any other phase of the heart beat. Both wounds were sutured with silk. The suture in the ventricular wound included the torn ends of the descending branch of the left coronary artery. The coronary vein was probably also torn but as the patient's condition became desperate at this point careful observation could not be made. The heart stopped beating entirely. Careful massage and adrenalin into the heart muscle started it again. The chest was quickly closed.

Aspiration obtained 1,800 cc. of air and blood. Oxygen and blood transfusion improved the patient's condition and he was finally sent to the ward in fair shape. Throughout the night the condition remained fair. In the morning the patient was fully awake and again exhibited the fright-pain so characteristic of coronary disease. Morphine in heavy doses was given but it was exceedingly difficult to keep the patient quiet. He was constantly pulling off the oxygen mask, screaming and rubbing his left shoulder. Tapping of the chest obtained 400 cc. of blood and 300 cc. of air but gave no noticeable relief. The pulse became weak, thready, and irregular. The blood pressure could not be maintained. The patient became more and more dyspneic as the day wore on. By evening he presented the typical picture of cardiac failure with numerous rales in both bases. Repeated aspiration of both pleural cavities showed no air or blood present. This patient died thirty-two hours after operation.

The heart was removed at autopsy and sent back to a Base Hospital for examination. Report received some time later stated that there was marked infarction in the region of ventricular wound with extensive muscle necrosis. This case, we believe, died a cardiac death as the result of the tearing of the descending branch of the left coronary artery with subsequent infarction. In view of the damage to this artery the fright and the shoulder pain, so outstanding in this case, is of particular interest.

CASE III. E. J. a patient twenty-six years of age suffered a single shell wound. The time of wounding was 1:30 A.M. and time of operation 6:00 A.M. There was a single wound of entrance just above and medial to the left nipple. The left fourth rib was shattered and the wound was sucking air. The patient was deeply shocked and dyspneic. Blood pressure was 68 systolic and 40 diastolic. Wound toilet was carried out under local anesthesia. Finger exploration revealed a large hole in the pericardium. Patient was then switched to pressure anesthesia and the shattered fourth rib resected. The pericardial sac was found full of blood and sucked dry. The

sac filled again with blood. The usual trapdoor incision was made and the pericardium exposed. The pericardial opening was enlarged and a tear about one inch long was seen in the anterior aspect of the right ventricle. The wound appeared to be of the tangential type and the actual hole into the ventricle was approximately one third of an inch in diameter. The heart wound was closed with interrupted silk. The pericardium was not sutured. The wound was closed in the usual manner.

The patient was in fair shape when he left the table but soon after his return to the ward became quite dyspneic. The left chest was aspirated and 4,000 cc. of air withdrawn without relief. It was quite obvious we were dealing with a wound of a bronchus with pressure pneumothorax. A needle was inserted into the upper anterior aspect of the left chest and strapped into place. This was connected to an underwater drain. Little relief was noted. The right chest was needled. It was found that a pressure pneumothorax had developed there. An underwater tap was installed on this side also. Oxygen and blood transfusions had little effect. The patient's condition deteriorated. He died twenty-eight hours after operation.

Post mortem examination showed that fragments from either the shell or the shattered fourth rib had not only wounded the heart but had also torn a large hole in the bronchus to the upper left pulmonary lobe. Another fragment had penetrated towards the right and torn a hole in the right pleura. This fragment had penetrated through the right lung and into the soft tissues of the back. The pressure pneumothorax arose from the hole in the left secondary bronchus but as there was a direct communication between the right and left pleural cavities it manifested itself on both sides. The heart was removed and sent back to a Base Hospital. The pathological report did not reach us.

CASE IV. S. S. was a twenty-two year old patient who had been wounded by a rifle bullet. This man was on patrol and was lying on his belly peering over a slight rise in the ground when a sniper shot him from in front. The wound of entrance was just inside the nipple line above the fourth rib. The time interval between wounding and operation was five hours. On admission he was in profound shock. Blood pressure, 72 systolic and 48 diastolic. He was not dyspneic but the abdomen was rigid and tender all over. Intestinal sounds were absent. The chest wound was trimmed under local anesthesia and finger exploration carried out. A hole about one inch in diameter was found in the pericardial sac. Patient was given pressure anesthesia and the fourth rib resected. The pericardial sac was found full of blood. This was sucked dry only to refill again.

The pericardium was exposed and opened freely. A tangential wound of the apex was immediately seen. The wound was about one inch long in the muscle but the opening into the ventricular cavity was about three millimeters in diameter. A small stream of blood spurted from it during systole. The wound was easily sutured with silk. It was then seen that the

bullet wound had penetrated downwards through the diaphragm and that most of the blood probably had escaped into the peritoneal cavity. The chest wound was hurriedly sutured in the usual manner and the left pleural cavity needled. Eight hundred cc of air and 200 cc of blood were obtained.

After further resuscitation an upper right rectus incision was made. The abdominal cavity was found full of blood and was sucked dry. No perforations could be found. It was noticed that there was considerable retroperitoneal hemorrhage. The gastrocolic omentum was incised and two holes found in the posterior aspect of the stomach. The bullet had plunged into the left lumbar muscles without injuring either the spleen or the kidney. The perforations of the stomach was sutured with silk and the abdominal wound closed. The patient, after a few stormy days made an uneventful recovery.

It is to be regretted that electrocardiographic and roentgen studies could not be made in these cases. During the interval before operation, when resuscitation measures were instituted, and during the postoperative period these studies would have been particularly interesting. Unfortunately this type of equipment was not carried by Field Surgical Units. In justice to the Royal Canadian Army Medical Corps I feel some explanation should be made of the long time interval between wounding and operation. All these cases were evacuated to us under very trying circumstances. The time interval includes that required for resuscitation after the patient had arrived at the advanced Surgical Centre.

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## Editorial

### MEDICAL AID IN THE FUTURE

FROM all reports it looks as if we will not have Socialized Medicine this year, at least. That some form of medical and hospital aid will be forthcoming for those in the low bracket income group and for the needy is more than a possibility. The majority are for this type of assistance, but the great majority do not want it under a complicated political structure administered by politico-laymen on the make. In many States, voluntary insurance is catching on and seems to be the answer to many problems. In New York State alone the four existing prepaid medical care plans approved by the Medical Society of the State of New York as of December 31, 1946, has approximately 600,000 members. When the directors of the various approved plans and the physicians themselves present the advantages of such plans to the public and the public has been made aware of the great benefits of these voluntary systems . . . in other words, when the public has caught the idea in a big way, and when belonging to such a "plan" has become universal, then we will not have to worry about compulsory health insurance under Federal control.

However, every one opposed to compulsory health insurance as proposed in the present bill, must consider himself a means of spreading propaganda. He must be a means of educating the public by

educating his patients. We are too prone to sit back and do a lot of wishful thinking, continuously leaving it to a few to carry on the actual task. Those who want this bill to become a law never rest on their oars one minute. They are well organized and every day they blast the members of Congress with propaganda dressed in many guises. Often this propaganda is untruthful and disregards the true facts. But if you pound a thought often enough into listening ears, sooner or later that thought will be accepted as truth. Therefore, in County and State Medical societies, in physicians offices at social gatherings we also must spread the true gospel and explain why compulsory health insurance misses the mark by a wide margin in its aim to provide adequate care for the sick and indigent.

T. S. W.

*Announcement:* Dr. Thomas B. Noble, Jr., of 1008 Hume-Mansur Building, Indianapolis, Indiana, has asked us to make the following announcement. Any one interested can contact the doctor directly at the address herein given. We quote from Dr. Noble's letter as follows:

"I have put together sets of 2 by 2 lantern slides and phonograph records with discussion and description, that may be had as loans for temporary use in

instruction or analytical study. There can be no profit to these packages.

"A surgeon, hospital groups, interns or others interested may have these studies for the asking, if they will give them reasonable care and return them or send them on to the next fellow. There is an almost universal availability of these miniature projectors, a screen and a phonograph. These and an audience are all that are required. The expense of sound movie projectors, the lack of detail for study in 16 mm. movie film, and the lack of opportunity for prolonged study of any scene, have encouraged me to get this sort of

visual education under way as an experiment and as a study of surgeon's response.

"So far, I have prepared sets on two related subjects, 'Adhesions of the Small Bowel, Meckel's Diverticulum, and Plication'; and 'Adhesions, Obstructions, and Plication.'

"The trial balloons have been well received, so that I have been encouraged to get several sets ready on each of the above subjects. Whether or not other subjects are treated so, until we have covered the entire field, depends on the interest aroused among surgeons."



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# Original Articles

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## POSTERIOR COLPOTOMY FOR DIAGNOSIS OF PELVIC DISEASES

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THE use of the vaginal route for removal of pelvic organs and for the diagnosis of pelvic diseases has been little used in the past few decades. Prior to the advent of modern abdominal surgery, however, many pelvic surgeons considered this the approach of choice for the removal of the uterus and its appendages.

In recent years Heaney,<sup>1</sup> Danforth<sup>2</sup> and others have revived the vaginal method for hysterectomy. About ten years ago Babcock<sup>3</sup> reported his experience with the vaginal approach for the surgery of the pelvic organs and described the technic of posterior colpotomy.

Except for hysterectomy in selected cases and the rare removal of a tube in ectopic pregnancy, posterior colpotomy for pelvic surgery is now rarely employed.

However, the literature in recent years contains many references to the use of colpotomy and cul-de-sac aspiration for the diagnosis of ectopic pregnancy. In 1908 Howard Kelley<sup>4</sup> said in discussing aspiration: "It is an old diagnostic measure and one of value to use a small aspirating needle to puncture the vaginal vault and withdraw some dark fluid blood. He who has done this in a case of presumptive pregnancy can afford to be very wise and very positive as to his diagnosis."

Greenhill<sup>5</sup> found pelvic puncture useful and said there was seldom need to perform colpotomy although in an occasional case the pregnancy mass may be removed

through the colpotomy incision. Burch and Seitchick have reported their experience with cul-de-sac aspiration in ectopic pregnancy.<sup>6</sup> They believe the margin of diagnostic error is reduced by its application. Schauffler and Wynia<sup>7</sup> found that cul-de-sac puncture was harmless and exceedingly valuable in the diagnosis of extrauterine pregnancy.

Williams and Corbit<sup>8</sup> have reported an analysis of 101 fatalities from ectopic pregnancy. They believe that errors or delays in making a correct diagnosis were responsible for a large proportion of sixty-five postoperative deaths.

McFarlane and Sparling<sup>9</sup> performed cul-de-sac puncture in ten cases of suspected tubal pregnancy. They conclude that the value of the procedure lies only in differentiating collections of blood and pus and that a negative needling does not exclude ectopic. In seven of the ten cases the patients had very stormy courses which were attributed in part to the introduction of infection through the puncture wound. These results outweighed any diagnostic value of the procedure.

Recent editions of Crossen and Crossen *Diseases of Women* and Curtis *Text Book of Gynecology* do not mention colpotomy or aspiration as a diagnostic measure in ectopic pregnancy.

At the present time the consensus of opinion is that the procedure confirms the presence of dark fluid blood in a large per-

## Decker—Colpotomy

MARCH, 1947

centage of cases. A fairly high percentage of negative needling occurs which does not exclude the presence of blood. Opinions differ as to the safety of the procedure as it is presently performed.

In most clinics aspiration of the cul-de-sac as a diagnostic measure is reserved for cases of ectopic pregnancy where the history and physical findings are atypical, producing a doubtful diagnosis. Incision and puncture of the posterior vaginal wall are performed when the wall is bulging with a suspected accumulation of fluid or pus. There has been no reference in the literature to the use of cul-de-sac puncture as a diagnostic measure in pelvic diseases or conditions other than ectopic pregnancy. Wide incision of the finger have been used on exploration by the operating room procedure. Puncture by trochar or needle is a minor procedure and does not require operating room facilities or technic.

Puncture of the posterior vaginal wall into the peritoneal cavity when performed in the lithotomy position is of no diagnostic value when free blood or pus is not obtained or is not present. Failure to obtain free blood when present results from failure or inability to enter the posterior pouch.

Incision or puncture of the bulging posterior vaginal wall in the lithotomy position is a simple procedure. When the posterior pouch is normal, particularly in obese women, the pelvic peritoneal cavity is not always readily entered when the patient is supine. It is frequently difficult or impossible to know when the pouch has been entered since in the absence of blood or fluid in that position there are no confirmatory signs.

Heaney<sup>10</sup> reports that in the course of the operation for vaginal hysterectomy the posterior cul-de-sac is occasionally difficult or impossible to enter.

These facts may account for the loss of popularity of cul-de-sac puncture as a diagnostic measure in some clinics. Undoubtedly inability to enter the pouch with

the patient in the lithotomy position accounts for the failures of the needlings in the presence of free blood and probably for the occasional occurrence of infection. In an attempt to increase the application of colpotomy as a diagnostic measure in many types of pelvic disease and conditions the puncture has been employed while the patient assumes the knee chest position. This method simplifies the procedure and makes it safer. The puncture is attended by less discomfort and the percentage of failures to enter the peritoneal cavity have been reduced. Also, the presence of the needle or trochar in the pelvis may be confirmed even in cases where blood or fluid are not present. This position also allows for a simple and safe puncture by a trochar with a cannula large enough to admit an endoscope for visualization of the cul-de-sac puncture, now termed cul-

doscopy<sup>10</sup> has been previously reported. The purpose of this report is threefold. It is intended here to emphasize the safety, simplicity and reliability of cul-de-sac puncture when performed in the knee chest position. Some of the details in experience thus far gained will be related and the value of endoscopic visualization in several cases will be demonstrated by case reports. Opinions and conclusions as to the value of culdoscopy in some gynecological conditions will be related.

When a patient assumes the knee chest position and the perineum is elevated the vagina distends. The posterior vaginal wall becomes thin and elongated and the distance between the cervix and the rectum is increased. This septum frequently becomes only a few millimeters in thickness.

This results from the increase in the intra-abdominal negative pressure created by the elevation of the diaphragm, the displacement of the abdominal viscera toward the diaphragm and the relaxation of the anterior abdominal muscles. The negative pressure created in the abdomen by this position measures as much as 25 cc. of water as determined by the Zavod aneroid

The posterior vaginal wall becomes thinned to a degree that is readily punctured with a No. 22 gauge needle with very little discomfort. When a few cubic centimeters of 2 per cent novacaine are injected into the septum, it may be painlessly punctured with a trochar and cannula.

When the posterior vaginal wall is punctured in the knee chest position and provision is not made to prevent the entrance of air, a spontaneous air pneumoperitoneum of from 600 to 1,800 cc. will occur. The amount depends upon the size of the patient and the relaxation of the abdominal muscles. The author has utilized the phenomenon of spontaneous pneumoperitoneum as an aid in x-ray diagnosis<sup>11</sup> of pelvic and abdominal disease in women and to test tubal patency.<sup>12</sup>

Since the preliminary report concerning this method of pelvic diagnosis the technic and the instrument employed have been improved. A short description of the present technic will be given here.

Cul-de-sac puncture by needle or trochar may be usefully employed for the following purposes: (1) To determine the presence of fluid or blood in the peritoneal cavity or in the extraperitoneal spaces; (2) for the introduction of air or CO<sub>2</sub> into the peritoneal cavity as an aid in x-ray diagnosis or for their therapeutic effect; and (3) for the endoscopic visualization of the pelvic organs.

When the puncture is made to remove fluid or to introduce air or CO<sub>2</sub>, the procedure is extremely simple. Little preparation is necessary. The bladder and rectum should be emptied. The patient is placed on the table in the knee chest position. The perineum is elevated with a Sims speculum and the vagina is wiped dry and painted with an antiseptic solution. The cervix is grasped with a tenaculum and drawn down, a 4½ inch No. 22 gauge needle is attached to a 20 cc. syringe and the plunger is drawn half way out. The point of the needle is poised over the posterior vaginal wall in the mid-line just above the cervix. The point is pushed through into the cul-de-sac. The presence of the needle

point in the pelvic peritoneal cavity will aspirate the air in the syringe and draw the plunger down. If it is desired to produce an air pneumoperitoneum the syringe is removed and the needle held in place. Air will enter the peritoneal cavity as long as the position is maintained or until the intra-abdominal negative pressure is neutralized. When it is desired to substitute CO<sub>2</sub> for air, a length of rubber tubing attached to a bag containing CO<sub>2</sub> may be attached to the needle.

When the purpose of the puncture is to determine the presence of fluid or blood a small trochar and cannula are employed. These are constructed so as to prevent a spontaneous pneumoperitoneum. After the puncture the sharp trochar is withdrawn into the cannula. When this has been accomplished the patient lies on the abdomen and turns slowly to the lithotomy position. During this change in position the examiner secures the cannula so that it does not slip from its pelvic position. When the supine position is assumed the trochar is removed and the fluid pelvic contents may be aspirated or flow freely from the pelvis through the cannula.

This procedure will result in a greater percentage of successful punctures. It will reduce the danger of entering the rectum or prolapsed segments of bowel and thereby reduce the incidence of infection. The author has observed no evidence of infection in four hundred punctures by needle and trochar. In the absence of fluid or blood positive proof of entrance of the needle into the pelvic peritoneal cavity is gained by the negative pressure phenomenon.

When the puncture is made for the purpose of endoscopic visualization of the pelvic organs some details for the preparation of the patient should be observed.

The patient is given 100 mg. of Demerol or 3 gr. of sodium amytal forty-five minutes before the examination. In the absence of apprehension the preliminary medication may be omitted. The vulva should be shaved and the rectum and bladder emptied. Operating room facilities and technic



are not necessary. A table equipped with upright leg holders and shoulder braces is essential. The patient is placed on the table in the knee chest position and the thighs are immobilized by bandages or thigh straps to the upright leg holders. The shoulders are secured by the braces.

The perineum, buttocks, vulva and vagina are painted with a non-irritating antiseptic solution. The patient is draped with sterile towels. The perineum is elevated with a Sims speculum and held by an assistant. The cervix is grasped with a curved volsellum and drawn down. Three or four wheals of 2 per cent novacaine are injected in the posterior vaginal wall just posterior to the cervix. In some instances this septum will be found so thin that air will be heard to rush in through these small puncture wounds.

The trochar and cannula are introduced through the posterior vaginal wall. The cannula is equipped with a valve to prevent the spontaneous entrance of air through the grooved trochar. A bag containing CO<sub>2</sub> may be attached by rubber tubing to the valve and the gas is allowed to enter the peritoneal cavity instead of air. CO<sub>2</sub> has the advantage of quick absorption. When early ambulation is desired this procedure is recommended. When the flow of CO<sub>2</sub> has ceased, the trochar is removed and the culdoscope is inserted through the cannula. The pelvic organs and the pelvic peritoneum can usually be well visualized.

The size and position of the uterus can be determined and its surface inspected. The presence of adherent structures and pathological changes such as serosal cysts, exudated, adenomyosis, endometriosis and small tumors can be verified.

The ovaries can be minutely inspected and the presence of adhesions or pathological changes can be visualized. The location and size of the ovaries can be verified and an estimate made of their physiological activity.

The serosal surface of the tubes can often be completely examined. The tubes may be observed in their adherent position

about the uterus or broad ligament or observed hanging free in the pelvis. Serosal tubercles or adhesions and thickened tortuous tubes are discernable when present. Indigo carmine may be introduced through the cervix by means of a self retaining cervical cannula. The dye can be seen to drip from the abdominal ostium when the tube is patent. An unruptured ectopic pregnancy may be seen by culdoscopy. All the local disturbances of tubal rupture or tubal abortion can be observed.

Puncture of the posterior vaginal wall into the pelvic peritoneal cavity by means of a needle or trochar has been employed more than four hundred times. The puncture was made in most instances for the purpose of endoscopic visualization of the pelvic viscera. In some instances it was used as an aid in x-ray diagnosis. A number of cases were used to study the extent and duration of the intra-abdominal negative pressure. No punctures were made for the purpose of therapy by intra-abdominal air. Recently some minor therapeutic measures have been attempted such as aspiration of cysts and release of thin adhesions about the ovary and tube.

These cases were selected from the Gynecological Service of the Knickerbocker Hospital, the Gynecological Clinic of the New York Post Graduate Medical School and Hospital, and from private practice. The observations were made during the past three and one half years.

The cases selected have presented clinical evidences before examination that varied from a normal pelvis or minimal amount of pelvic disease to large palpable tumor masses. Many of the early cases were selected because they presented minimal amounts of pathology. Some cases were examined in the presence of extensive pathological processes to determine the limitations of the procedure. Many routine preoperative examinations have been made that have verified the findings and the technic. The number of cases that presented real diagnostic problems is small as compared to the total number of cases ex-

amined. For that reason a statistical analysis will not be attempted here. There have been some errors in interpreting the gross pathological changes.

The diagnosis made have included the following:

#### UTERUS

Normal uterus, small serosal cysts, small myomas, sessile and pedunculated, adenomyosis, tubercles of the serosa, endometriosis; adhesions to the omentum, sigmoid, ovaries, illium and fixed retrodisplacement of the uterus to the sigmoid.

#### OVARIES

Normal ovaries, recent follicular activity. Small sclerotic ovaries, no evidence of recent follicular activity. Small follicle or luteum cysts; adhesions of the ovary to the uterus, to the broad ligament and to omentum, endometriosis of the ovary and large ovarian cysts.

#### TUBES

Normal tubes, acute salpingitis, chronic salpingitis, tubo-ovarian inflammatory masses, tubal adhesions to pelvis, to omentum and to intestines, patent tubes, tubal occlusion, tubercles of the serosa, unruptured ectopic pregnancy and hydrosalpinx.

#### PERITONEUM

Exudated, endometriosis, tuberculosis and blood and fluid in the peritoneal cavity.

Culdoscopic visualization has been used as a diagnostic aid in several gynecological problems. The following case reports are given to illustrate its application. It has been usefully employed when there was a difference of opinion as to the presence or absence of pelvic pathology and when an accurate diagnosis could not be made by other means.

#### CASE REPORTS

CASE I. Culdoscopy is of particular value in the case of the indefinite pelvic mass in

which there is a difference of opinion as to the location and extent of the pelvic pathology.

This is illustrated by the case of Mrs. J. M., age thirty-two, whose chief complaint was severe pain in both lower quadrants. The patient was treated in the clinic for three months without relief before being referred to the Knickerbocker Hospital for surgery.

The previous surgical history included an appendectomy in 1928, tonsilectomy in 1922 and a hemorrhoidectomy in 1943. There had been a dilatation and curettment for incomplete abortion on October 10, 1944. This was the third admission to this hospital. At her last admission in October, 1943, x-rays of the gallbladder, gastrointestinal tract, kidneys and spine were negative.

The menstrual period began at the age of thirteen and the intervals have been irregular, twenty-five to thirty days. The flow has been moderate and accompanied by some low back pain the first day. The history was otherwise normal.

The physical examination was essentially negative except that palpable pelvic masses were described at several examinations in the clinic. After admission to the ward, the pelvic diagnosis by three of the attending staff were not in agreement.

A culdoscopic examination was performed on January 23, 1945. This examination revealed the following; the uterus was normal in size and position. At the left cornu there was a small sessile fibroma about  $1\frac{1}{2}$  cm. in diameter. The tubes and ovaries were observed to be normal. There was no pelvic pathology to account for the patient's chief complaint.

Because of the persistence of symptoms, a laporotomy was performed on January 26, 1945. Observation at laporotomy confirmed the culdoscopic findings in detail.

CASE II. Mrs. P. B., a twenty-one year old white woman, was admitted to the hospital March 1, 1945, complaining of vaginal bleeding for three days with severe abdominal pain. The bleeding was scant for two days but became profuse before admission and was accompanied by cramp-like pains more severe in the right lower quadrant. The last regular menstrual period was January 20, 1945.

There had been no previous abdominal surgery. There had been two pregnancies resulting in one child and a miscarriage with curettment on August 1, 1944.

The examination revealed a young woman of plethoric constitution who guarded her right

abdomen against examination. There was a systolic murmur at the apex. The abdominal wall was flat and characterized by marked tenderness in the right lower quadrant.

Her temperature was 99°F., the blood pressure was 120/80 and 115/60 on two different days. The hemoglobin was 86 per cent, erythrocytes 3,450,000, leukocytes 5,100 of which 79 per cent were polymorphonuclear and 30 per cent lymphocytes. The urinalysis and Kahn and Kline blood tests were normal. The Friedman pregnancy test was negative.

There was a difference of opinion as to the pelvic findings and diagnosis.

Pelvic examination by A. D. on March 6, 1945, described the entroitus as normal. The cervix is directed posterior and is very tender on motion. The external os is closed. The uterus is anterior and not enlarged, but very tender on manipulation. There is an indefinite fixed mass in the right adnexal region which is extremely tender. There is tenderness in the left adnexal region but no palpable mass. Impression: Right chronic salpingo-oophoritis.

Pelvic examination by W. F. on March 7, 1945, described a large mass in the right adnexal region, fixed to the uterus. The mass is sausage shaped. Impression: Ectopic pregnancy, advise laparotomy.

Culdoscopic examination was performed on March 8, 1945. The colpotomy was made without difficulty. The uterus was normal in size and anterior. The serosa was normal. The left tube was observed to be thickened, tortuous, and adherent to the ovary and to the posterior surface of the broad ligament. The left ovary was cystic and adherent. The right tube was clubbed, the surface was covered with recent exudate, and it was adherent. The right ovary was enlarged to 4 cm., and contains a small cyst. It was adherent by thin adhesions to the sigmoid. The left tube was normal. Culdoscopic diagnosis: Right salpingitis.

CASE III. The following case illustrates the use of colpotomy with visualization in the differential diagnosis in a case of pelvic endometriosis.

Mrs. A. P. was a twenty-three year old Porto Rican admitted to the hospital on January 7, 1946. She complained of pain in the lower abdomen, more marked in the left lower quadrant, and irregular vaginal bleeding for the past three months. The pain was intermittent and cramplike and was aggravated by the menses. She had been treated in the outpatient

department for the past six weeks and had been referred to the ward for surgery. The previous surgery consisted of a laparotomy in May, 1942, in Porto Rico because of pain in the right lower abdomen. The patient states that the right ovary was removed. Pathological reports were not available.

There had been three pregnancies. The youngest child is two years old. Pregnancy, delivery and puerperum were normal in each instance. For the past two years menses have been irregular twenty-four to thirty days and profuse for six days with co-menstrual pain for the first two days.

Examination on admission revealed a temperature of 101°F. which was maintained for two days. The pulse was 94 and the blood pressure 108/80. The hemoglobin was 13.8 Gm. The erythrocytes were 4,550,000 and 13,900 leukocytes, 84 per cent were polymorphonuclear. The urinalysis, blood, Kahn and Kline were normal. The heart was normal and the lungs were clear.

The pelvic examination revealed no evidence of infection of Skene's ducts, Bartholin glands or the uterine cervix. The cervix was posterior, closed and tender on motion. The uterus was normal in size, firm, anterior in position and painful on manipulation. There was tenderness in the right fornix but no palpable mass was felt. The cul-de-sac was free.

The preliminary diagnosis was residual chronic pelvic inflammatory disease following laparotomy or endometriosis.

Culdoscopic examination was advised and made on January 1, 1946. The puncture was made without difficulty. The pelvis was well visualized. The uterus was normal in size. The omentum was adherent to the corpus near the right cornu. The right adnexa was not present and not visualized. The intestine was adherent to the right side of the uterus and to the right broad ligament. There was a dark, irregular cystic mass about 1 cm. in diameter on the posterior surface of the uterus. This area had the appearance of endometriosis. The left tube and ovary were normal. The left ovarian ligament was normal. The pelvic peritoneum was normal and there were no other evidences of endometriosis.

Culdoscopic diagnosis: Endometriosis of the uterus. Omental and intestinal adhesions.

Experience appears to support the conclusion that cul-de-sac puncture for diag-

nostic purposes is best employed in the knee chest position. When combined with endoscopy it is a useful adjunct to the present methods of diagnosis in obscure pelvic disease. It is believed that culdoscopy will gain in favor among pelvic surgeons who earnestly desire to avoid unnecessary pelvic operations.

Culdoscopy has made possible a definite diagnosis in several cases of severe menstrual disorders when the pathological change was not demonstrated by other means.

In the study of sterility the cul-de-sac puncture and endoscopy afford all the information that is gained by tubal insufflation, most of the information obtained by uterosalpingogram plus visualization of the ovary and an estimation of its role in the sterility. The estimation is made by the presence or absence of recent follicular activity and by the relation of the fixed abdominal ostium to the ovary as well as by presence of adhesions about these structures.

At the present time inspection of the ovary is the most reliable method for determining that ovulation is to take place or has just occurred. These conditions are evidenced by the presence of fully mature follicles or follicles that have recently ruptured or are at the time of inspection exuding fluid. The presence of the unhealed or healing follicle crater and fresh corpus luteum are significant. The ovaries may be safely, conveniently and repeatedly examined by culdoscopy without hospitalization.

Present methods also permit the aspiration of mature or nearly mature ovum from the ripened follicle as has been suggested to the author by Dr. John Rock.

Occasionally during vaginal hysterectomy it has been necessary to interrupt the operation and to abandon the vaginal route. This is usually due to undiscovered pelvic disease or pelvic adhesions. Also occasionally when surgery is advised and attempted for the relief of sterility, pathological processes are disclosed at laparotomy that make the contemplated

procedure impossible, or at best uncertain of results. It is believed that preoperative visualization would be harmless and useful in these cases.

**Contraindications.** Cul-de-sac puncture cannot be performed through an intact hymen or when disease or atrophic conditions make the introitus and vagina inadequate. It should not be employed in the presence of acute vaginal infection or when the cul-de-sac is filled with a fixed mass that does not move out of the pouch upon assuming the knee chest position.

It is contraindicated in cases of decompensated heart disease or debilitated conditions that do not permit assumption of the posture for even a few moments.

**Complications.** There has been no incidence of peritonitis, abscess or hemorrhage in any case in which the cul-de-sac was punctured in the knee chest position. There have been no complications in any case where culdoscopy was carried out. The post examination course has been afibrile, and except for a variable amount of distress where air pneumoperitoneum was produced, has been without symptoms in all cases. When the procedure was used preoperatively no evidence of infection or injury was observed at laparotomy and the postoperative course was normal.

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# PRIMARY CYST OF THE ROUND LIGAMENT

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THE purpose of this paper is to present a case of true cyst of the round ligament, to summarize the embryology of the structures involved and to review the available literature.

True primary cysts of the round ligament are rare. There are many reports in the literature of the occurrence of solid tumors of the round ligament. Adenomyoma, leiomyoma, endometrioma, hygroma (cystic lymphangioma), cystic degeneration of solid tumors, dermoids and lipoma have all been described. Any swelling in the inguinal region is usually mistaken for an incarcerated inguinal or femoral hernia. It is not surprising then that the diagnosis is not made except at operation.

True cysts of the round ligament must be lined by columnar or cuboidal epithelium. Cystic degenerations of solid tumors have no lining epithelium. Hygroma are usually thin-walled compressible cysts which appear after birth, are congenital and grow rapidly; they are multilocular, contain serous fluid and are lined with epithelium. The case which we are presenting is one of true cyst because the lining wall consisted of low cuboidal epithelium.

Kershner and Shapiro<sup>30</sup> were able to find only nine case reports of cysts of the round ligament in the literature, only four of which were verified histologically as true primary serous epithelial cysts of the round ligaments. They added three true cysts of the round ligament of their own.

The earliest report of a cyst of the round ligament was made by Stanley and Skey in 1854.<sup>49</sup> In one case incision yielded three pints of fluid which kept recurring. In a second case they just mention a cystic swelling occurring in the inguinal region.

In the third case they tapped the cyst which yielded serous fluid. The cyst kept refilling. None of these were operated upon. Only from their description one might infer that they were cysts of the round ligament.

In 1859, Coulsen<sup>11</sup> reported a case of cyst of the round ligament but there was no microscopic report.

In 1896, Cullen quoted Aschenheim, who described a similar instance of a walnut-sized cyst in the inguinal area attached to the uterine round ligament. This contained a clear fluid. The micropathology is lacking.

Tausig, in 1914, in a review of fifty-three cases of tumor of the round ligament, mentions three cysts without giving further descriptive data. He further reports a total of 141 cases of tumor of the round ligament in the literature. A report on the pathological nature of the tumors in 135 of the 141 cases was found: 79 were fibromyoma, nineteen cysts, one dermoid, thirty adenomyomas and six sarcomas. The nineteen cysts reported had no micropathology. Kershner and Shapiro,<sup>30</sup> in 1943, in reviewing the subject, were able to find nine cysts of the round ligament. Micropathology reports were available on four. These investigators added three cases of their own with the micropathological reports revealing them to be true cysts.

In a thorough review of all the available literature, twelve authentic cases of true cyst of the round ligament with microscopic pathology were found. The present report brings the total to thirteen.

Of the fifty-two cases reported in the literature, those of Aumann,<sup>1</sup> Brohl,<sup>8</sup> Giglio,<sup>20</sup> Heller,<sup>23</sup> Kershner and Shapiro,<sup>30</sup> Martin,<sup>37</sup> Schnedorf and Thomas,<sup>45</sup> Ulezko-Stroganova,<sup>51</sup> and Vassmer<sup>52</sup> are to be

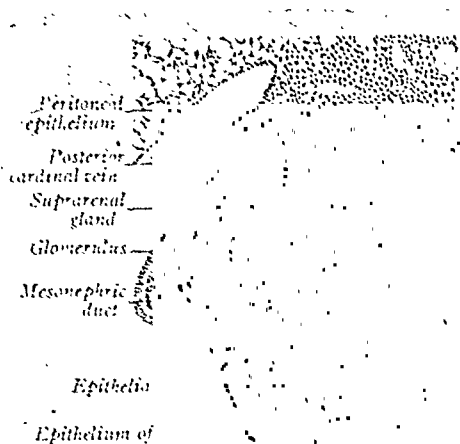


FIG. 1. Urogenital ridge attached broadly to mesentery.

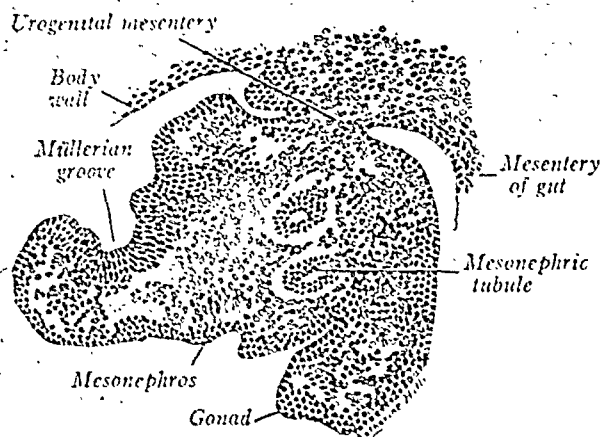


FIG. 2. Development of a common urogenital mesentery.

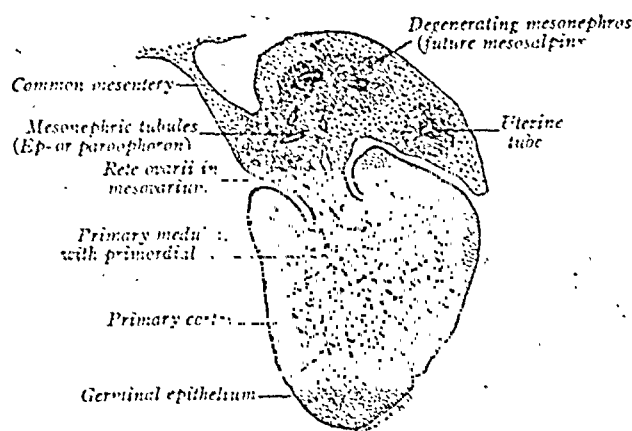


FIG. 3. Development of mesocarian and mesosalpinx (eighth week of gestation).

considered cases of true cysts using the criteria mentioned above.

#### ETIOLOGY

The etiology of cysts of the round ligament must be due to embryological anomalies. The entire urogenital apparatus is derived from the mesoderm.

The ligaments of the female genital system are also developed from the mesoderm. They are derived from the caudal portions of the mesenteries of the mesonephros. Thus cystic structures in these areas may represent persistent embryological rudiments.

A review of the development of the round ligament is presented.

At six weeks the urogenital ridge is attached broadly near the root of the

gut mesentery. (Fig. 1.) But soon a common urogenital mesentery suspends the gonadic mesonephric regions. (Fig. 2.)

Towards the end of the second month there develop definite ligamentous supports for the internal genitalia. These are comparable in both sexes, but only in the female do they become structures of permanent importance. The ovary is primarily suspended by a short mesentery known as the mesovarium which becomes prominent as the gonad outgrows the mesonephros. (Fig 3.) The remains of the primitive genital ridge at the more cephalic level persists as the suspensory ligament. (Figs. 4 and 5.)

Similarly, the terminal portion of the genital ridge unites the caudal end of the ovary first to the transverse bend of

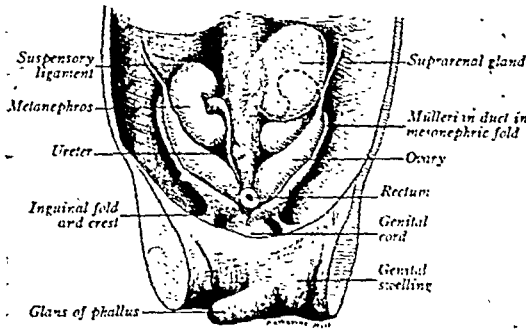


Fig. 4. Suspensory ligament of ovary. (From cephalic end of primitive genital ridge.)

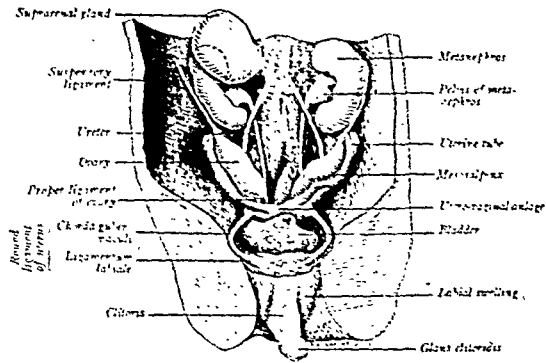


Fig. 5. Proper ligament of the ovary. (From caudal end of primitive genital ridge.)

the urogenital ridge and then to the uterus which develops in it. The connection becomes fibromuscular and is known as the proper ligament of the ovary. (Fig. 6).

the ovary and uterine tubes descend to a lower position. The mesovarium and mesosalpinx are intimately associated with the broad ligament. (Same as Fig. 4.)

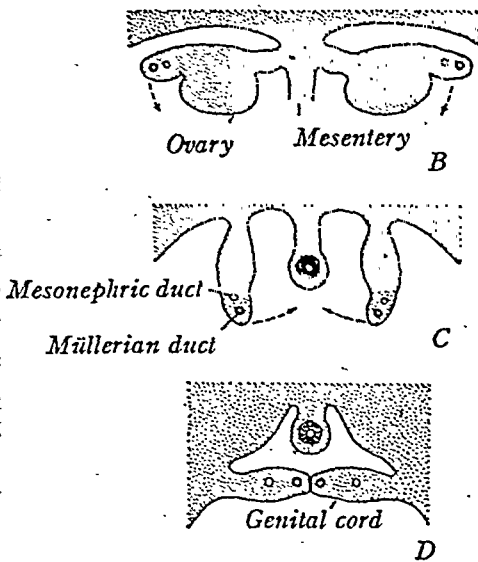


Fig. 6. Development of genital cord.

With the degeneration of the mesonephric system the uterine tube lies in a mesenterial fold, the mesosalpinx. Somewhat earlier the mutual fusion of the caudal portion of the two urogenital ridges produces the genital cord. (Fig. 7.) A mesenchymal shelf now appears in the frontal plane between the two lateral body walls, and contains the uterus in its center. (Fig. 8.) The shelf persists as the broad ligament on each side of the uterus, after

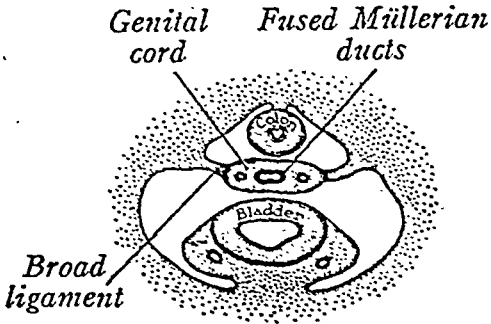


Fig. 7. Development of broad ligament.

During the seventh week another and more complicated ligament of the uterus appears at the level where each urogenital ridge bends horizontally towards the mid-plane in forming the genital cord. An outgrowth, the inguinal fold, bridges across to a prominence, (the inguinal crest) on the adjoining abdominal wall. (Same as Fig. 5.) Within these parts is differentiated the gubernaculum which later becomes a fibromuscular band. The abdominal muscles develop around its canal to end in the form of a tubular inguinal canal. At the outer end of this canal the cords connect with a second band that extends to the labial swelling of the external genitalia, ligamentum labiale. By the beginning of the third month the chords gubernaculi and

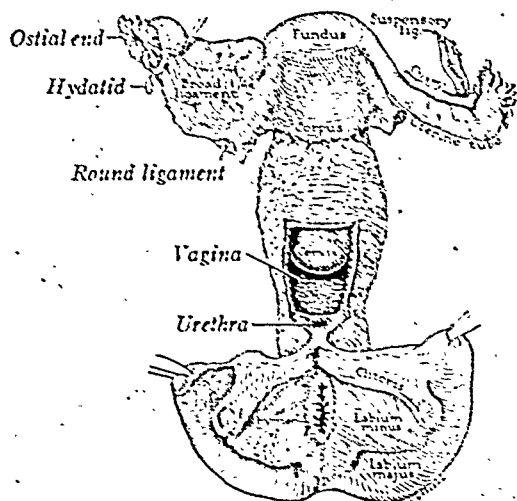


FIG. 8. Close relationship of mesosalpinx and mesovarium to broad ligament.

the ligamentum labiale extend as continuous mesenchyma units from the uterus to the labia major. The combined cord is known as the round ligament. (Fig. 9.)

The round ligament is a muscular structure in its upper third; it contains smooth muscle fibers springing from the external muscular layer of the uterus. These fibers run for the most part along the anterior margin of the ligament to its middle third. The lower third consists of the same smooth fibers with an admixture of a considerable number of cross striated fibers, analogous to the cremaster fibers in the male. Intermingled with the muscular elements one also finds on the outer portion of the round ligament some elastic fibers.

For a true cyst to be found in a structure consisting of muscular and elastic elements, would imply that the etiology is in developmental anomalies of the Wolffian bodies.

#### CASE REPORT

Mrs. A. S., was admitted to the hospital on June 15, 1943, with a complaint of a lump in the right inguinal region for the past six months. The lump was about the size of a large walnut. Occasionally she would get a cramp-like pain in the right leg. On lying down she noticed that the lump would get smaller. On standing she noticed it would get larger. She complained of no tenderness or pain.

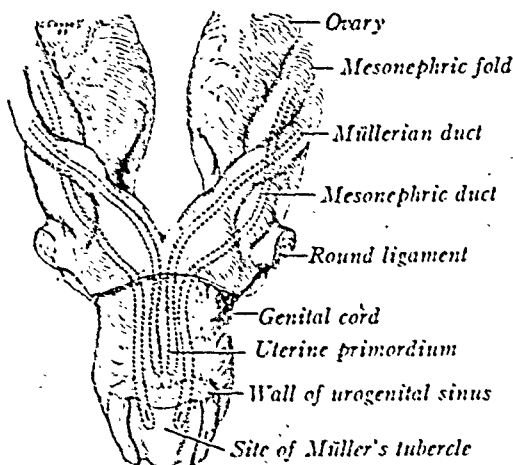


FIG. 9. Course of the human urogenital ducts and formation of genital cord. (Model at two months.) The close proximity of the mesonephric body and duct (Wolffian) to the beginning of the round ligament (inguinal fold).

A year and a half ago the patient had a hysterectomy and a left oöphorectomy for uterine fibroids and a left ovarian cyst. Physical examination revealed nothing essentially abnormal except for a mass in the right inguinal



FIG. 10. Microscopic picture of lining of cyst removed showing one layer of flattened cuboid epithelial cells.

region which was partly reducible. No pain or tenderness were present. The impression was that an indirect inguinal hernia was present. At operation a mass containing fluid was found about the size of a large walnut attached to the round ligament. The outer end of the round ligament was excised and the cyst removed.



The abdomen was closed in a manner modified from repair of inguinal hernia.

The pathological report was as follows: June 15, 1943, Lab. No. S-430-43: Gross: The specimen consists of an irregular cystic structure measuring 5 by 3 by 3 cm. The wall is thin and in places is bluish, containing air bubbles; in other places the outer aspect is covered by fibrous tags. Upon incision a clear yellow fluid exudes. The inner lining is smooth, shiny and grey. The second specimen is an elongated piece of skin measuring 8 by 0.5 by 0.2 which is firm and pale grey. Microscopic: The cyst is lined by one layer of flattened cuboid epithelial cells. The wall consists of a thin layer of fibrous connective tissue. A portion of skin shows atrophy of the epithelium and mild chronic inflammatory changes in the subcutis. (Fig. 10.)

#### SUMMARY

1. A review of all available literature on true cyst of the round ligament is presented.

2. The embryological development of the round ligament and of the female generative organs is presented.

3. True cysts of the round ligament are rare; all have been diagnosed only at operation.

4. The etiology of these cysts is believed to be a developmental anomaly of the Wolffian body.

5. A review of the literature reveals only twelve cases of true cyst of the round ligament found with micropathological description. Another case is added.

6. Of all the tumors of the round ligament, a true cyst of the round ligament is the rarest.

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# TISSUE CULTURE AS A CLINICAL AID IN THE DIAGNOSIS OF MALIGNANT TUMORS

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AS long ago as the time of Hippocrates, in the Fourth Century, B. C., tumors, both benign and malignant, were known clinically. In A. D. 150, Galen and his school were still engaged in the study. Galen classified tumors as benign or malignant, although he admitted both types were contrary to nature. Benign tumors, he taught, arose from various tissues, but never destroyed the tissues. Malignant growths were destructive and tissue destroyed by them was never replaced.

This view parallels the modern statement that *all cancers are tumors, but all tumors are not cancers*. What is of extreme importance to the clinician of today is, which type of tumor is present in a given case. The field of cancer research is so immeasurably large that no one engaged in it can afford to neglect any diagnostic aid which will throw light on the urgent question of what constitutes malignancy.

It has long been known that different tumors spring from different tissues: fibromas from connective tissue; angiomas (birth marks, port wine marks) from blood vessels; chondromas from cartilage; osteomas from bone; lipomas from fat. Laennec found that all cells spring from cells of the same kind.

Weiss,<sup>1</sup> commenting on the activities of the cell, divided them into: cell proliferation and movements (morphogenesis); cell differentiation (cytogenesis); development of parts from the whole (organogenesis); finally, adaptation. He names the major tissues in the embryo as nerve, muscle, connective tissue and epithelium.

A great many workers have followed the lines laid down by Carrel more than thirty years ago. An excerpt from the New York

Times, January 16, 1932, commented upon the thirtieth anniversary of the embryo chick heart fragment, known as the "old strain," first cultured in special medium, at the Rockefeller Institute by Carrel. Carrel retired in 1939, and Dr. A. H. Ebeling, one of his co-workers, took the culture to the Lederle Laboratories, where it has since been maintained by special feeding, administered by special nurses. Given the right medium, it is immortal.

Despite this historical landmark and the multiplicity of workers who have followed in this field, very little clinical help has emerged from tissue culture work. This is because insufficient attention has been paid to the difference of behavior in benign and malignant cells in tissue culture.

Workers agree that the cellular activity seen in tissue culture is not always the cellular makeup of the original tumor, and a review of the literature raises the question whether some cellular elements from the cancer bed were not cultured, rather than the actual cancer cells.

In my original paper<sup>2</sup> I have stated that this is unquestionably what happened and it seems probable that what we grew in tissue culture was fibroblastic material, or the resisting tissue of the cancer bed. This fact might have much clinical significance as a therapeutic approach.

Gladys Cameron,<sup>3</sup> a co-worker with Robert Chambers in his Biological Laboratory at New York University, states that malignant tissue is more difficult to maintain *in vitro* on account of its power of liquifying the medium to a marked degree. The fibrin support of the cell is destroyed. The cells float up, become separated and finally die. In many types of tumor, however, by special methods of tissue culture,

the cells have been successfully cultivated for several months.

Cameron finds that in tissue culture there is no striking difference between cells grown from normal and malignant tissue, except that, in the latter, the organization is less regular; but in the *behavior* of the cells the difference is striking. Neoplastic malignant cells show destruction of fibrin, and in carcinoma there are often thick, ugly strands of epithelium, instead of the clear transparent sheets of normal cells. Another difference has been noted by Fischer<sup>4</sup> and other workers, namely, that a single malignant cell can increase and multiply, while normal cells can only do so in the presence of other cells.

Fischer<sup>5</sup> has worked out a method for providing support for malignant cells. Instead of fibrin, he provides a piece of dead muscle as a support for the cells. He puts the muscle and tumor side by side in the culture medium. The sarcoma cells pass into the muscle and thus undue liquifaction is avoided.

Among the advantages derived from tissue culture, Cameron finds that tumors can be more readily identified than by section. The cells retain definite characteristics. Thus breast tumor formation shows acini and fat droplets in the cells which indicates a continuation of function, just as the culture of renal tubules shows continuation of renal secretion.

Tumor cells have to be cultured in such a manner that they are not overgrown with connective tissue. A careful technic is needed in that the amount of embryonic extract must be reduced and the frequency of transfers has to be cut down in order to avoid overgrowth of stroma cells and fibroblasts.

It was formerly considered that the stroma cells were necessary for the growth of the tumor cells, but recent work has shown that the epithelium of mammary carcinoma grows with production of acini, without any fibroblastic tissue at all. The latter inhibits the growth of epithelium by mechanical means. It probably functions

as an effort on the part of nature to wall off a foreign body. However, if the tumor cells manage to reach out through the connective tissue and infiltrate the surrounding tissues a dangerous condition is formed. It is supposed that metastasis of tumors takes place via the lymph channels and blood vessels.

Boyd<sup>6</sup> says, "In a study . . . of malignant growth two factors may be detected: there is the destructive and anarchistic tendency of the tumor cells, but there is also the restraining influence of the tissues . . . for instance, in carcinoma of the breast histological evidence may often be found where groups of tumor cells have been strangled or encapsulated by fibrous tissue."

Fibrosis is a phenomenon which explains why a patient can live many years without medical or surgical supervision. It also illustrates the glaring error which the surgeon makes in taking credit for saving the life of the patient with scirrhus carcinoma of the breast by radical surgery when, quite possibly, it has fibrotic body defense quite sufficient to preserve the patient's life.

William Bloom<sup>7</sup> states that "with few exceptions, adult tissues have not been cultured successfully. During their development they have lost the power to adapt themselves to the new environment. Earlier in their existence they live and multiply in culture. For example, at a certain stage a group of cells becomes identifiable as renal and are not identical with cells of other types of organs."

D. R. Coman<sup>8</sup> of the University of Pennsylvania, derived cells from peritoneal and pleural fluid, due to malignant neoplasms and cultured them by the roller tube method. He reports that macrophages, polymorphonuclear leukocytes, lymphocytes, mesothelial cells and fibroblasts were cultured from all fluids. In one instance endothelial cells were found and this provided cultures resembling capillaries. The cells from carcinoma and sarcoma were cultured and grew vigor-

ously, thus indicating that such cells remain viable and capable of proliferation in pleural and peritoneal fluids, if given a satisfactory surface to which they can become attached. Small colonies were seen to develop from single neoplastic cells that had become isolated in the supporting plasma of the tissue culture. The significance of these observations is discussed as opening the field for further exploration. He says that the culture of cells from pleural and ascitic fluid can be of aid for diagnosis in favorable circumstances.

M. E. Sano and L. W. Smith<sup>9</sup> have used tissue culture as a diagnostic aid in hard-to-classify tumors. They state that doubtful cases of tumors are sometimes not recognized, even at autopsy, and go down in the records as unclassified tumors. In such cases tissue culture is an additional diagnostic aid in identifying the type. They cite two cases in which this procedure has confirmed a tentative diagnosis.

#### CASE REPORTS

**CASE I.** A white woman, thirty-six years old, showed multiple, small, subcutaneous nodules, distributed all over the body, non-pigmented and freely movable. Five years previously she had had a pigmented nevus removed from below the knee, by a physician, who diagnosed the growth as "benign nevus, pigmented." One year before admission the patient noticed a small nodule in Scarpa's triangle. This was excised after full Roentgen treatment. The diagnosis was "metastatic melanoma." It recurred promptly. At the present admission the nodule showed no pigmentation. Biopsy showed an atypical, spindle-cell tumor, non-pigmented. A fragment was kept for tissue culture. The patient died three weeks after admission. Autopsy showed widespread visceral metastases in all organs and subcutaneous tissue. The cells were uniform in size and staining qualities, but non-pigmented. The specimen was instantly put into the refrigerator at 1°C. and forty-eight hours later transplanted to Lewis tubes on cover glass containers. Medium used: Calf embryo extract, chicken plasma and tyrode solution. Fourteen days later fibroblasts, clasmotocytes with deep staining pigment were distributed evenly

through the cytoplasm; some granules were nearly black and there were black granules lying loose in the medium. Small pseudopodia were present. The diagnosis was malignant melanoma, showing amelanotic features clinically. The appearance of pigment in culture was due to changed metabolic activity.

**CASE II.** A boy, eighteen months old, had a marked supraorbital swelling and swollen glands of the neck after a cold. The biopsy showed an atypical lymphosarcoma. The growth was maintained six months. At that time we could not obtain suitable embryonic extract, and the cells shrunk and appeared crenated, but on again providing suitable medium, they migrated and proliferated.

The authors claim that, as the knowledge of the appearance of the various types of cells increases, the utilization of tissue culture methods will assume increasing importance in the diagnostic field.

In writing of tissue culture of various types of cancer Jean Verne<sup>10</sup> in the chapter headed "Comportement des Cancers en Culture" states that the culture of the various types of cancers showed an evolution peculiar to each of them and necessitated particular technic methods in each case. The culture medium is frequently liquified, which called for various cultural artifices. . . . certain plasmas or sera have an inhibitory effect on proliferation of cancer cells; on the other hand we must recognize formative and stimulating substances, such as hepatic tissue, testicular tissue of cancerous animals, thyroid, genital or salivary glands and embryonic tissue, which all favor proliferation. Kidney and spleen tissue, on the contrary, have inhibitive action. Fischer points out that, contrary to normal tissue, cancerous elements can be grown from a single cell.

Verne further states that, morphologically, cancer shows augmentation of chromosomes and formation of giant cells. Sarcoma shows two types of cells—fibroblasts and ameboid cells. He cites Fischer and Carrel who said that the macrophages constitute the sarcomatous cells. This for two reasons: (1) according to Fischer, when

the sarcoma cells take on purely fibroblastic aspect, they have lost their malignancy; (2) in the Rous Sarcoma, it is the macrophages which fix the virus.

A Mexican worker, L. B. Soto,<sup>11</sup> quotes O. Bucher's opinion that all malignant neoplastic cells possess phagocytic activities, in which opinion Soto concurs. He comments upon the proteolytic and glycolytic properties of these cells. He finds that cells arising from mesenchymal structures are the easiest to culture, also that the life of the neoplastic cell is shorter than that of the normal cell. Malignant cells rapidly produce toxic substances. Soto has succeeded in producing immunity by antibodies, the latter of pure neoplastic cells. He cites the work of Carrel and Fischer in transforming normal cells into tumor cells.

The author believes that in low-grade, well differentiated tumors it is possible that the radiologist may adversely alter the status of cellular differentiation. This problem must be approached biologically in order to be sound therapeutically.

The foregoing investigations by numbers of independent workers show that considerable work has been done in observation of the cancer cell in tissue culture. The data should be examined and classified to show how the more malignant types can be differentiated from benign forms in tissue culture and what diagnostic significance can be attached to the picture.

The author's<sup>2</sup> earlier investigations, made over a period of years, were conducted at the biologic laboratories of Washington Square College of New York University, under the auspices of Prof. Robert Chambers. In this series the operations from which the specimens were taken were usually done about 9 A.M. and cultured in the early afternoon of the same day. Medium: 2 volumes of the following: 1 vol. chicken blood plasma; 3 vol. human serum; 1 vol. embryonic extract. Twelve to fifteen explants were made from each tumor.

The various tumors showed difference in behavior from each other in from twenty-

four to ninety-six hours after culturing. This suggested that such differences might be related to the grade of malignancy of the tumor as seen clinically. It was assumed that different types of behavior in tissue culture might have diagnostic significance in cases of tumor difficult to classify by ordinary methods.

In a series of thirty-seven diverse tumors reported, fifteen others had to be excluded from the list, on the ground of contamination, or other factors. As the number of each class of tumor was small the results of that series had to be regarded as tentative. It has to be emphasized here, according to Cameron<sup>2</sup> that tumor tissue, taken from an area contaminated at its source, is not suitable for culture, as, for example, tumor tissue from the skin, or G.I. tract. The following case illustrates this point, also points in differential diagnosis:

A patient, male, thirty, lawyer who was first seen March, 1941, gave a history of having had a nevus on the right thumb. This was struck and became infected. Home treatment was futile. He then had a series of roentgen treatments which cleared up the infection. He was advised biopsy and excision. Examination showed a swollen right thumb, with an ulcer 5 mm. in diameter, tender and filled with fluid. There were palpable axillary nodes and râles in the chest. Operation on the thumb was done shortly after. The pathology report showed "squamous cell carcinoma of skin of thumb." *Tissue culture could not be done on the nevus growth which was contaminated.* The axillary node, however, was cultured for five days. It showed growth of wandering cells, fibroblasts and leukocytes; *no epithelium* (malignant cells). This diagnosis has been borne out by the subsequent history. The axillary nodes have disappeared and the patient is well today, with no signs of recurrence.

In reviewing the progress that has developed in this field since my first publication, 1941, it is evident that despite the meager evidence and crude methods of interpretation, the work did have definite clinical value. Considerable work has been done since in the Chambers laboratory.

C. G. Grand, Robert Chambers and Gladys Cameron<sup>12</sup> succeeded in growing mouse and human melanomas in tissue culture. They found the implanted fragments tended to render the medium very alkaline. They neutralized this by growing fragments of normal tissue in the same medium. When there were many fibroblasts present, the material did not become alkaline. Three types of cells occurred in the outgrowth, viz: macrophages, fibrocytes and melanoblasts, the latter being spherical cells and highly dendritic. They contained melanin granules in irregular clumps throughout the cytoplasm. The fibrocytes possessed little melanin. In the melanoblasts, melanin was found in the dendrites and the periphery of the main cell body. Phagocytic activity was observed chiefly in the macrophages. The melanoblasts were very sluggish, the cell remaining in one position for days. The pigment granules could be seen moving within the dendrites. The melanoblasts were easily recognized in the culture by their morphological characteristics.

Further studies on neoplasms were carried out by Gladys Cameron and Robert Chambers.<sup>13</sup> In these investigations human tumors were cultured for from three to four months, in a medium consisting of chicken plasma, human serum, and chick embryonic extract. When discontinued the cultures were growing rapidly.

In primary carcinoma, it was essential to avoid fibrocytic growth. The nodules had to be dissected from the dense fibrous tissue. The sequence of cells which migrated from the explant was in this order: leukocytes, shortly followed by lymphocytes five or six hours after incubation; macrophages within twelve hours; fibrocytes in from twenty to twenty-four hours; epithelia, rarely before twenty-eight hours. Cameron and Chambers showed that in:

*Primary Mammary Carcinoma:* (A) Small groups of cells emerging from the explant, developed into hollow nodules indicating acini, of which some were grouped, some

isolated. Eventually the acini spread out into flattened sheets. (B) Intracellular fatty globules, typical of mammary gland epithelium, were observed only within cells comprising the acini. In stained specimens the epithelium of the acini stained more intensely than the epithelial sheets.

*Lymph Node Metastases of Mammary Carcinoma:* Acinar formation was infrequent or absent.\*

*Lymph Node Metastases of Squamous Cell Epithelium:* Concentric development of cornified epithelium, surrounded by fibrocytes, appeared in culture after 8 to 10 days. These simulated the so-called 'Pearls' which characterize the tumor.†

*Angio-endothelioma:* Endothelial columns and tubes developed in the medium and progressively branched and increased in size. In this there also appeared melanoblasts, highly pigmented macrophages and cells identified as neuroglia.

In the mammary and parotid tumors, the formation of acini was most pronounced in regions where fibrocytes were scanty.

Cameron and Chambers, with C. J. Kensler,<sup>14</sup> made studies on the effects of chemicals on cancerous cells and on normal cells. They found that human mammary carcinoma cultures, exposed for twenty-four hours to a concentration of 0.002 of heptanal, followed by a return to normal medium, underwent a slow, progressive, and complete disintegration of the epithelium in four to five days.

\* This is quite logical, because the undifferentiated cells in any cancer are the ones most likely to metastasize, and in the grading of cancer by the clinician the fundamental factor in prognosis depends on the type of cell dominating the primary tumor. The growth dominated by well-differentiated cells will have a good prognosis, with a bad outlook almost always attends the opposite phenomenon. This biological fact, unfortunately, is not sufficiently appreciated by many surgeons, who often, unduly, claim so-called cures in low-grade neoplasms, crediting technical proficiency, rather than biological phenomena.

† Although "cancer pearls" were noted in the metastatic node, this being the differentiated element of the primary squamous cell growth, this is not usually the dominating characteristic in the lymph nodes.

In contrast to this the epithelium of normal human mammary gland cultures, and the fibrocytes and lymphocytes in cultures of either normal or malignant tissues, were not affected by prolonged exposure to concentrations up to and including 0.007 M.

In the same laboratory, differential diagnosis of Hodgkin's Disease lymph nodes from other lymphomas and from normal lymph tissue, has been carried out by C. G. Grand<sup>15</sup> by tissue culture methods. The lymph nodes were obtained surgically from Memorial Hospital, New York, and from the Hodgkin's Disease Laboratory of St. Vincent's Hospital, New York. The lymph nodes were from early and late stages of the disease. As controls, normal lymph nodes were used, also nodes from various lymphomas (twenty lymphosarcomas, fifteen leukemias) and from several metastatic carcinomas and lymphadenitis cases.

The cultures were maintained for periods varying from a few days to several weeks. The migrations on the explants were as follows: *twenty-four hours*—granulocytes, eosinophiles and lymphocytes; *forty-eight hours*—macrophages, reticulocytes and fibrocytes; *forty-eight to seventy-two hours*—large, multinucleated giant cells with oval nuclei. These appeared on the periphery of the explant. The nuclei surrounded a large, grayish, granular region, generally occupying the central portion of the cell. These cells, known as Reed-Sternberg cells, were typical of every case of Hodgkin's disease, but absent from other lymphomas and from normal lymph nodes. The cells increased in number and size the longer the culture was maintained.

The granules of the central body of the Reed-Sternberg cells stained deeply within fifteen minutes, with brilliant cresyl blue, the color varying from red to purple. These inclusion bodies were also seen in the fibrocytes, macrophages and lymphocytes, similarly stained.

Cells from normal lymph nodes inocu-

lated with supernatant extract from Hodgkin's disease, when cultured, also showed cell inclusions, when stained with brilliant cresyl blue.

Supernatant fluid, injected on to the surface of the chorioallantoic membrane of hens' eggs, of six to eleven days incubation, showed, after six more days' incubation, clusters of vesicles, 1 mm. in size, containing clear fluid. These lesions were cultured forty-eight hours and then stained with brilliant cresyl blue. They showed the cell inclusions seen in the original tissue culture. No control tissue produced this result.

This highly significant contribution to establishment of an accurate diagnosis of Hodgkin's Disease in the difficult field of adenopathies, supports the original request of the writer, in 1941, that this method of differentiation be incorporated as a routine procedure in cancer study. Clinicians realize, only too well, the present difficulties in reaching an unassailable diagnosis in this disease. The recent studies quoted confirm the earlier work done by the writer, namely, that the behavior of tumors under tissue culture, is diagnostic, both as to activity and probable malignancy of the tumor, and also as regards differentiating between different types of lesions. All workers in this field concur in the idea that malignancy of a neoplasm seems to go hand in hand with its tendency to liquify the culture medium.

The writer's interest in this problem arose from association with Miss Cameron, Dr. Chambers and the late Dr. Frey, although the latter, before his death, was not certain of the clinical interpretation given or willing to jointly publish the original paper. In that study<sup>2</sup> it was found that, under culture conditions, tumors evince three characteristics, (1) degree of liquifaction of the medium; (2) migration of wandering cells, irregularly spherical in shape, probably leukocytes and macrophages; (3) migration of more or less spindle-shaped cells which



are fibroblasts and arise from connective tissue. These latter, in tumor tissue, migrate early and abundantly from the explant. In normal, adult, mammalian tissue, there is a latent period before growth is initiated.

In 1929, the writer examined and graded a series of cases of carcinoma of the breast, grading them arbitrarily according to their relative malignancy, approximately following Broders' technic,<sup>16</sup> as follows:

I	II	III	IV
No liqui- faction of the medium and no vis- ible cell ac- tivity:	Slight liqui- faction, few wandering cells.	Much liqui- faction, many wandering cells.	Much liqui- faction, many wan- dering cells, plus fibro- blasts.
<i>Benign</i>	<i>Low grade</i>	<i>Medium grade</i>	<i>High grade</i>

In our classification, Group I is definitely benign. This grading is highly important clinically, in order to avoid the numerous unnecessary operations, with attendant mutilation, that have been done on so-called "borderline" cases of neoplasms. No surgical pathologist can ignore this fact for a moment. Osler's<sup>17</sup> dictum of "As is your pathology, so is your practice" might be modernized to read "As is your biopathology, so is your practice."

This method of grading brought out the following points: the higher the grade of tumor, the greater the tendency to metastasize, and the further the metastasis from the primary site, the greater the malignancy. These facts call for such a method as tissue culture to grade neoplasms according to their property of proliferation and metastasis.

It was discovered also that the more the cells adhered to the normal parent architecture, the less they tended to metastasize. Conversely, the more they leaned toward undifferentiation, the more prone they were to metastasize. The importance, clinically, of distinguishing between the two types is seen in such a case as cancer of the colon. A well-differentiated adenocarcinoma will kill by obstruction unless removed surgically. On the

other hand, the type with undifferentiated cells will kill by metastasis. Thus factors of biopathology of the cell weigh strongly in estimating surgical prognosis.

In the group of high-grade, undifferentiated cell tumors, all the patients were dead in six months from the time of the tissue culture studies. Cultures showed a profuse growth of fibroblasts from the explant, while the original section showed very little fibrosis. It should be recognized that man's greatest cellular defense against cancer is his ability to lay down abundant fibrosis in the cancer bed, therefore our therapy should be directed to enhance the proliferation of fibroblasts as a biological defense.

In our series the benign tumors, (with one exception) showed no activity. Malignant tumors, (with one exception) showed much activity of various degrees. These two exceptions, however, cannot be ignored: (1) fibroid tumors of the uterus are considered benign, except for two per cent. In tissue culture, however, of eight cultured, four showed a slight activity, the rest none.<sup>2</sup> Metastatic tumors of the axillary gland (breast carcinoma) are definitely malignant, yet, three such tumors showed no activity at all in tissue culture. It is possible that in forty-eight hours we might have obtained a growth if we had allowed for a longer period of culture. To explain the discrepancy more time and critical study must be given to coordinate the findings in tissue culture in both primary tumors and metastatic nodes.

Oberling<sup>18</sup> considers the cancer problem to be closely associated with the organization of the cell. It appears in the same form in almost all animal species and even in plants, and suggests some impairment of some mechanism essential to life. The nature of the malignant process is identical, no matter what its origin.

The writer believes that one of the greatest errors made by physicians in cancer research has been in directing all their investigations to man alone, ignoring

the great fundamental biological principles involved.

To surgeons it is very apparent that cancer behaves in human subjects in many different ways, but the clinical picture always bears a definite relation to the cellular makeup of the neoplasm, the reaction of the tissue in the cancer bed, and the anatomic position of the growth. The cellular makeup of the neoplasm is biologically the most vital part of the problem. Atypical cell behavior, therefore, is the crux of the cancer problem.

In 1761, Fontanna wrote that research is a game of chance in which the probability of error is great, and the chance of discovery of truth small. Some clinically important facts remain steadfast, however, such as the observation by Fischer and other workers that cancer elements can grow from a single cell. This gives us a very important point in laboratory procedure. Another vital fact is the degree of fibrosis. The greater the fibrotic defense, the better the prognosis.

The writer is confident that if clinicians would consider the biopathological aspect of cancer research an infinitely sounder approach to therapy would immediately result. This has been neglected by physicians who have remained bound to old methods of diagnosis, prevalent for more than half a century, such as staining of dead, fixed cells by hematoxylin and eosin. Whereas attention should be centered on the growth habits of the living cell in suitable culture medium. MacCarthy and Broders at the Mayo Clinic have, for years, insisted on the necessity for cytologic study. In this the writer emphatically concurs. He feels that the biological approach to the problem would, if developed, save many patients untold misery and limit the magnitude of many surgical problems. The culture of living cells demands an important place in our armamentarium for combatting cancer, if any intelligent progress is to be made in our therapeutic efforts. At this most opportune moment, when so much na-

tional publicity is devoted to the cancer problem, it is a fatal error to support some fantastic or nebulous ideas in cancer research and neglect this practical and practicable contribution to accurate diagnosis. It is true that, while activity of migrating cells can be noted within twenty-four hours, periods of time from two weeks to a month are often necessary to produce a growth of tumor cells which are actually specific. Nevertheless, cell activity is something which can give us warning of possible danger to the patient. Cases can occur which baffle both the surgeon and the pathologist. An ancient slogan that went the round of the medical schools was, "If the pathologist says 'malignant' the patient will be all right." This proverbial jest may contain a grain of truth.

The writer insists that the tissue culture method has not been given sufficient trial. A group of hospitals could combine in making this a routine service, whereby, at least, the activity of tumor cells in culture could be noted and reported on after a twenty-four hour period, and a diagnostic landmark be obtained. The diagnostic tools of the past are outworn. On the scientific horizon there is no aid, potentially greater for service to the cancer patient, than this method.

Years ago, Virchow<sup>19</sup> stated "... nothing has penetrated less deeply into the minds of all than the cell-theory in its intimate connection with pathology ... the cell is really the ultimate morphological element in which there is any manifestation of life, and that we must not transfer the seat of real action to any point beyond the cell." Real progress in the field of cancer therapy will only come if we humbly return to this philosophy and start anew.

#### SUMMARY

1. Tissue culture work has been practised for more than thirty years, yet little help for the clinician has arisen from it.
2. Malignant tissue has the tendency to liquify the culture medium. Special

technic is necessary to avoid this if the cells are to be cultured over prolonged periods.

3. Tumor cells can be more readily identified by tissue culture than by section. The cells retain their functional characteristics.

4. Tumor cells that are atypical and hard to classify may be identified by tissue culture methods.

5. Malignant cells can proliferate from a single cell. This does not take place in normal tissue. This fact, with greater experience, may be a sign pointing the way to earlier diagnosis.

6. Increase in activity of tumor cell growth is related to their degree of malignancy.

7. The author has graded tumors into four classes, according to their degree of malignancy.

8. Tissue culture methods have been used to differentiate the nodules of Hodgkin's Disease from other lymphomas. This practical procedure in the difficult diagnosis of Hodgkin's Disease, should be universally used.

9. Tumors with differentiated cells have less tendency to metastasis than those with undifferentiated cells.

10. High activity of cells in tissue culture gives warning of danger to the patient.

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# RECURRENT DISLOCATION OF THE PATELLA\*

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**R**ECURRENT or habitual dislocation of the patella always occurs to the lateral side of the joint. The condyle, or basic underlying growth dysplasia which existed prior to the trauma. Genu valgum also causes stretching of

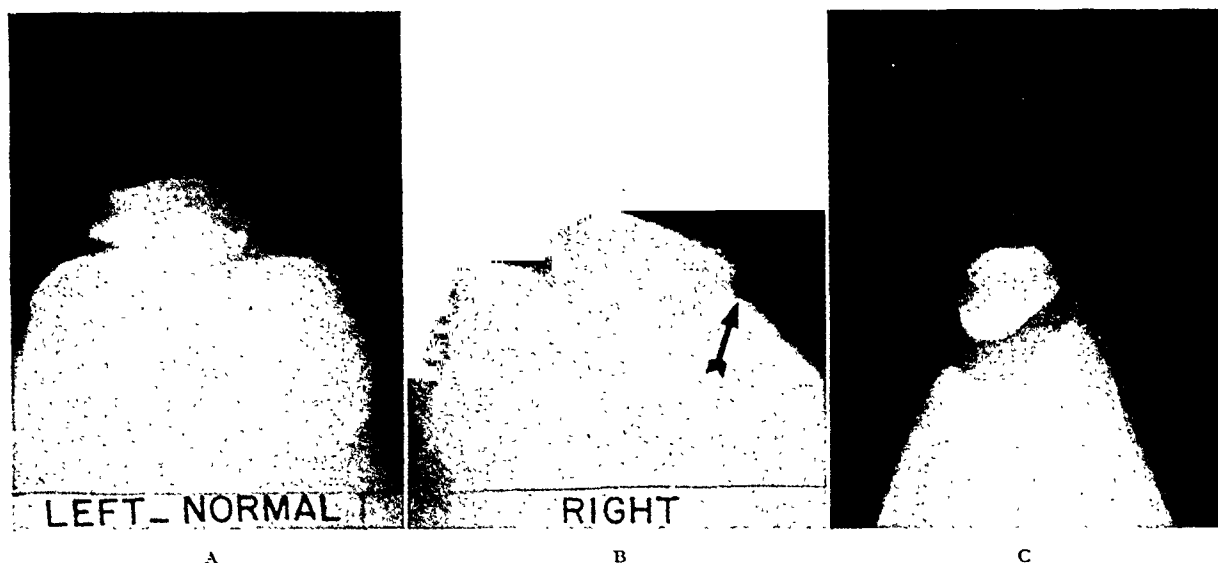


FIG. 1. A, represents normal contour of femoral condyles in vertical view. B, shows underdevelopment of lateral femoral condyle of moderate extent as encountered in cases with slipping patellas. C, extreme underdevelopment of lateral femoral condyle and deformity of trochlear surface.

patella slips over the lateral femoral condyle, causing the clinical appearance of a very prominent medial femoral condyle. Because of this prominence, the patient generally states that the patella moved inwards. There has, however, been no reported instance of dislocation to the medial side.

Trauma has been suspected of playing a part in initiating dislocation of the patella laterally. It is our opinion, however, that the recurrent cases have a primary basic underlying fault permitting dislocation to occur. Trauma may be the precipitating incident. All of our cases gave a history of original trauma of some degree, but the trauma was of a mild type, such as might happen to a normal knee without resulting in patellar displacement. Many of our x-rays show a bony under-development of the femoral

the medial capsular ligaments and promotes lateral mobility of the patella. Although most of these cases also show underdevelopment of the lateral femoral condyle, genu valgum, by altering the pull of the patellar tendon lateral to the midline of the femur, enhances the tendency to dislocation. Recurrent dislocation has occurred in rickets with marked genu valgum, and similarly in infantile paralysis. Clinically the structures attached to the medial side of the patella are usually much more relaxed than in the normal, even though it may not be possible manually to dislocate the patella.

The most important cause, nevertheless, for recurrent dislocation of the patella is an underdeveloped lateral femoral condyle. (Fig. 1.) This we believe to be congenital. One family in our series has shown a pronounced hereditary factor for habitual

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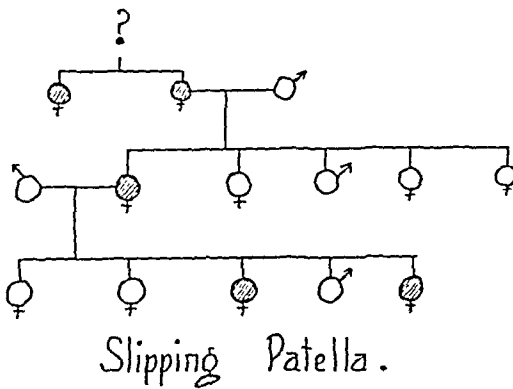


FIG. 2. Recessive trait of recurrent dislocation of patella encountered in one family.

dislocation of the patella. Since this hereditary factor has not been reported before; and since the factor is quite obviously a recessive gene in this particular family, it is thought to be worthy of mention in this report. (Fig. 2.) It was noted that the dislocation occurred among the females

of this condition whenever a suspected medial meniscus injury is observed in a girl. A torn medial meniscus is rather rare in girls and in more than one instance in our series, a diagnosis of "torn medial meniscus" had to be revised to one of "slipping patella."

Although in these patients the patella is supposed to be located at a more elevated level than in the normal knee, this is not always discernible from clinical examination or roentgenogram. In roentgen films the level of the patella is governed largely by the degree to which the knee is flexed. Even with the knee extended (an unusual roentgenographic view to take) it has not been possible for us to find pathognomonic elevation of the patella. In some lateral views a definite flattening of the anterior surface of the lateral femoral condyle can be seen.

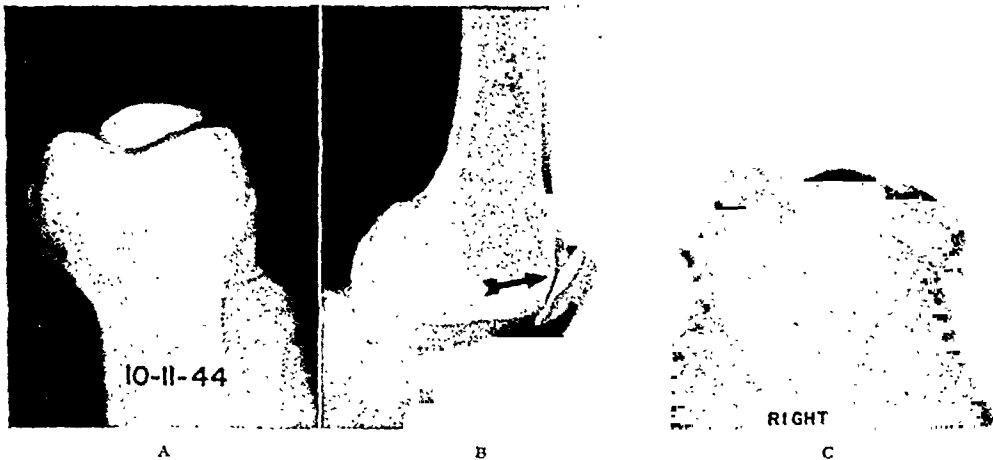


FIG. 3. A, tear-shaped formation of the patella frequently encountered with minimal flattening of lateral femoral condyle. B, flattening of anterior surface of lateral femoral condyle. C, illustration of case in which lateral dislocation of patella could not be prevented on flexion of the knee even by most forcible manual manipulation.

of this family and did not occur in the males. In our series of operative cases, all were females. As in congenital dysplasia of the hip, it is probable that the underdevelopment of the femoral condyle takes place in varied degrees in both sexes.

Since dislocating patellas are more frequently seen in females, and usually with a history that the knee suddenly gave away beneath them as they stumbled (or following a trauma), it is wise to think

(Fig. 3B.) This is the point over which the patella dislocates as the knee is being flexed. The most informative roentgenographic view has been one taken with the patient lying prone with the knee flexed so that a posteroanterior view of the femoral condyles is obtained. This has usually demonstrated that the lateral femoral condyle is definitely underdeveloped when compared to the normal knee. In some cases, there is an associated

change in the shape of the patella, with the patella being tear shaped, (Fig. 3A) rather pointed at its lateral margin, and with the bulk of its body toward the medial aspect of the knee. In the younger patients there has been no associated osteoarthritis of either the patellas or femoral condyles. In the older cases osteoarthritis has been observed, and associated with it there has occasionally been evidence of loose bodies in the knee. In some patients the tendency is so pronounced that the patellas will always dislocate when the knee is flexed. (Fig. 3c.) The patella cannot be held on the trochlear surface even when the examining hand attempts to do so. These severe types, of course, present no problem in diagnosis.

The first reported operative technic for this recurrent dislocation of the patella was by Heller in 1850. (Fig. 4A.) He attempted to tighten the medial portion of the capsule by scarification. Hoffa, in 1899, sutured the medial capsule after excising a portion of it. In 1900 Trendelenberg (Fig. 4B) inserted a bone peg into the superior surface of the lateral femoral condyle, to restrain lateral dislocation of the patella as the knee was flexed. Supracondylar osteotomy advised by Graser in 1904 was performed in cases of severe genu valgum. Goldthwait, in 1904, transplanted half of the patellar tendon medially to keep the patella in place. This was the first time the insertion of the patellar ligament had actually been changed in its line of pull. Tubby, in 1912, divided the capsule laterally to allow the patella to be displaced medially when the inner capsule was reefed. The division of the lateral capsule is the basic underlying principle for securing results. There is a very definite tightening of the tissues that run from the superolateral border of the patella toward, and extending into, the vastus lateralis. We have not found any specific transverse band, extending from the inferolateral aspect of the patella to the biceps tendon, as described by one author. There has been instead, a

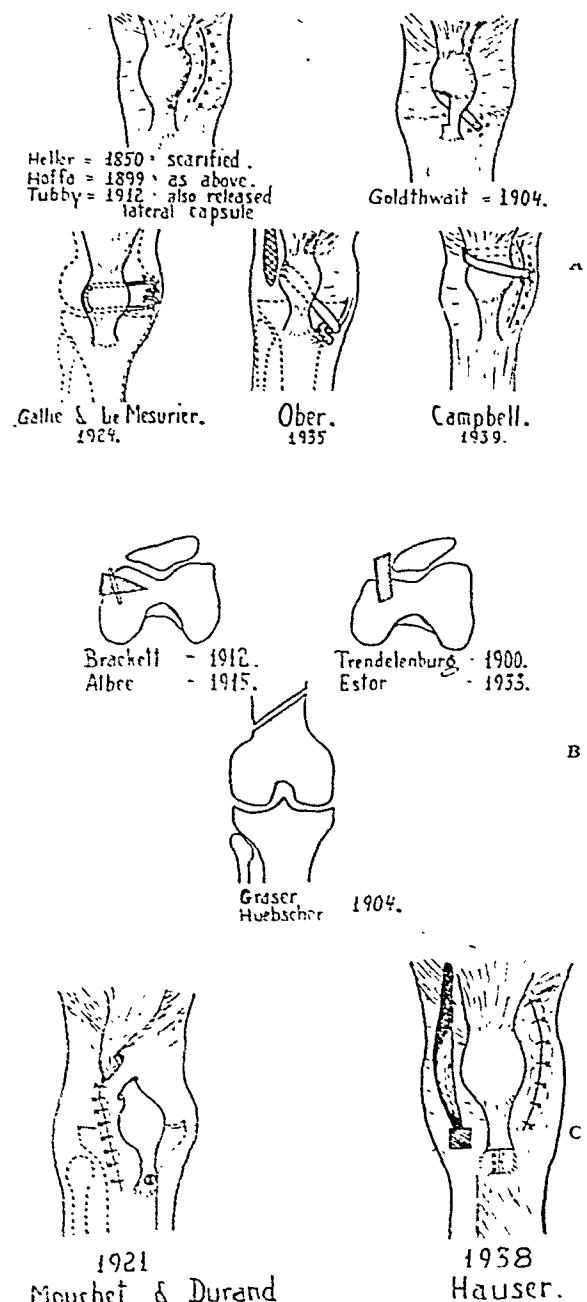


FIG. 4. Illustration of various operative procedures: A, on capsule; B, on bony parts; C, by transplantation of tibial tubercle.

general tightening of all of these lateral structures. It is important to divide these structures in any type of operation that is done.

Subsequent fascial operations have been devised by Gallie, by Le Mesurier and by Campbell, using fascial bands medially, to prevent the patella from dislocating in addition to dividing the tight lateral capsule.

Brackett, in 1912, operated on the bone as well as on the local tight fascia.

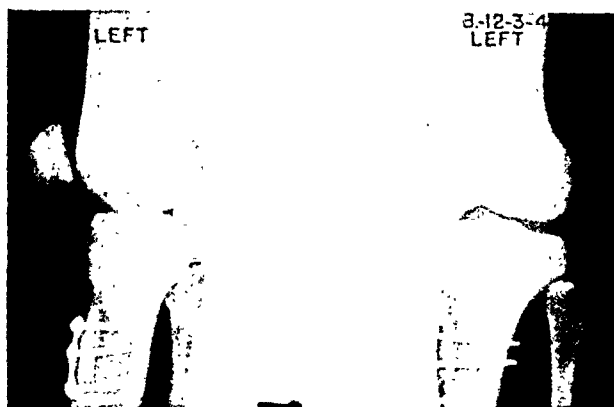


FIG. 5. Transplanted tibial tubercle anchored slightly distally and far medially by three-hole plate and three screws. Two screws hold tubercle down, prevent its rotation and imbed in the far cortex. The third screw anchors the whole transplant distally to solid tibia. Note that patella is held engaged on the trochlear surface, even with the knee extended, and is drawn to the medial side.

After dividing tight lateral fascia, he elevated the flattened lateral condyle and inserted a bone wedge to hold the raised portion in place.

Two French surgeons, Mouchet and Durand, in 1921, first changed the complete insertion of the patellar ligament more medially by redirecting the course of the patella and its tendon through a separate opening in the capsule. (Fig. 4C.) Without knowledge of their work, we tried this procedure on one case. The most recent bony operation for dislocating patellas is that reported by Hauser in 1938. He believed that the patella not only rode higher on the femur than normally, but that the patellar tendon was lengthened. To overcome these factors, the tibial tubercle was transplanted distally and medially.

While this operation has been extremely successful in our hands we have now modified the procedure to some extent. First, we incise the medial and lateral fascial structures, but do not plicate or suture the medial capsule. The operation seems to work successfully when this is not done. Second, we prefer to fix the tibial tubercle by a Vitallium plate and screws. Third, we employ a plate extending below the tubercle transplant to solid

tibia, and therein is placed another screw. Stability obtained by this type of fixation is markedly improved and allows earlier mobility and weightbearing with a shorter convalescence. Fourth, we avoid transplantation of the tubercle too far distally and judge the amount of medial displacement at operation after freeing the tubercle. Fifth, cast support for one week only is used.

#### CASE REPORTS

CASE I. C. L. H. The tibial tubercle was transplanted downward and medially and fixed with one Vitallium screw into the tibia. In her follow-up examination, the knee only permitted 90 degrees of motion for over a year but finally loosened up still further until now, five years postoperatively, she has a full range of motion.

CASE II. M. C. Operation was performed with a transplantation downward  $1\frac{1}{2}$  inch. The tibial tubercle was fixed in its new location with two Vitallium screws. This has resulted in a stable knee with full motion at five year follow-up examination.

CASE III. E. B. The tibial tubercle was transplanted under firm tension medially and downward about 2 inches, and fastened in place with a plate and two Vitallium screws. A long leg cylinder plaster was applied for six weeks. The patient was allowed to bear weight and

walk three weeks following operation. At the end of two and a half years, she had motion only from 180 to 90 degrees. The knee is stable, symptomless and the patella has not redislocated. The undue tension with prolonged encasement cost this patient motion.

CASE IV. J. M. The tibial tubercle was transplanted  $1\frac{1}{4}$  inch downward and medially and fastened in place with a plate and two Vitallium screws. One week postoperatively plaster retention was used. She fell and strained the knee three weeks postoperatively without loosening her transplant. She returned to duty as a student nurse in  $2\frac{1}{2}$  months. There was full range of motion less than seven months postoperatively. Absolute plate fixation and early motion promoted this favorable result.

CASE V. M. B. (Fig. 5) This nineteen year old girl was first diagnosed as having a torn medial meniscus but later was seen with a frank dislocation of the patella. At operation a recent hematoma of the medial capsule was discovered. Operation was performed using a plate with three screws. She was walking with a brace in two weeks. Follow-up examination shows an excellent result with full range of motion and no recurrence of the dislocation.

CASE VI. J. S. A forty year old woman, whose patellas had been slipping out of place since her early youth, was not possible to flex the knees and still hold the patellas on the trochlear surfaces. Both knees were operated upon. The lateral capsule and vastus lateralis were extremely tight. There was marked external rotation of the tibia as compared to the femur. The anterior tibial crest was fully 45 degrees to its normal position. On the right,

two screws were used to fix the tibial tubercle 2 inches downwards and medially. On the left, instead of the usual operation, the patella and its tendon were transplanted through the capsule after the operation of Mouchet and Durand. The tibial tubercle was then fastened to the tibia, as on the right. Extensive dissection was required. Hematoma, infection and necrosis occurred on both sides, leaving the right knee stiff and painful and the left knee unstable. We advise against similar extensive operative procedures.

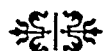
#### SUMMARY

1. We believe that flattening of the lateral femoral condyle is a frequent finding in roentgenographs of these knees. It probably represents a congenital hereditary recessive trait.

2. We believe that simple transplantation of the tibial tubercle medially, but not too far distally, with division of the medial and lateral capsule of the knee joint satisfactorily controls recurrent dislocation of the patella. It is not necessary to suture the capsule on either side.

3. The transplanted tibial tubercle should be fixed in place with a three hole plate and screws. The distal screw should be embedded in solid tibia. This promotes maximum stability and allows early mobility.

4. Little or no postoperative plaster support is indicated with the above plate fixation.





# COMMON ERRORS IN BURN TREATMENT

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THE treatment which a burned patient receives in the first two hours after injury will largely determine the outcome of the case. If he is properly cared for during this early period, there is hope for the patient's comfort and life; for it is during these early hours that the management of pain, infection, shock, nutrition, anoxia, toxemia, fluid balance, wound healing and numerous allied vital problems have their inception. The magnitude of their importance is so often unappreciated until too late that it seems desirable to stress some of the common errors in burn treatment.

The fact that burn management is rapidly changing and that the average physician treats, at most, one or two serious burns a year, makes errors understandable. McClure<sup>1</sup> aptly states that if the 7,000 deaths from burns occurring yearly in the United States "were equally distributed among the 130,000 practicing doctors, each would see only one fatal case in 18 years of practice."

## ERROR OF NOT RECOGNIZING A BURN AS A SURGICAL PROBLEM

If it is desirable to approach the operating table properly gowned and masked, how much more important it is to make a similar approach to burn wounds which by their very nature are parallel with the body surface and readily exposed to infection. The necrotic tissue so ideal for bacterial culture cannot be adequately débrided and must be protected from contamination. Inasmuch as the highest standards of surgical technic are habitually practiced by the operating room personnel, it is most desirable that burns be dressed in surgery.

The emergency rooms of most hospitals

are used for the determination of tentative diagnoses and the treatment of minor injuries (including infected wounds). Inasmuch as the diagnosis is obvious and the injury is a serious one, there is little reason to stop there except for a hypodermic for the relief of pain. The least desirable procedure is to send the patient immediately to his private room, where practically nothing is sterile.

## ERROR OF NOT RECOGNIZING THE EXTENT AND DEPTH OF A BURN

As in other forms of trauma, the severity of burns is often underestimated until many hours after injury when the alarming manifestations of weak pulse, lethargy, fever, nausea, vomiting, oliguria, bloody diarrhea, disorientation, etc., develop. Fortunately burn trauma is generally only skin deep, and one needs no x-rays or special tests to estimate its severity. Roughly speaking, any second or third degree burn involving 10 per cent or more of the body surface, or approximately the surface area of one upper extremity, is a candidate for hospitalization.

A hasty sketch of the burned areas on paper containing anterior and posterior views of the human body is of great assistance in helping one to estimate the percentage of body surface burned. Berkow's<sup>2</sup> estimation of body surface is as follows: (1) Upper extremities 18 per cent; (2) lower extremities 38 per cent; (3) back of trunk 18 per cent; (4) front of trunk 20 per cent; (5) head 6 per cent; total 100 per cent. The sketch so made may serve as the best physical examination on these patients for weeks or months and the percentage of burned surface noted will be of immediate value in estimating early plasma requirements.

The dryness and pallor indicative of third degree burns should be noted in such victims to aid one in meeting the problems of prolonged hospitalization, nutrition, infection, contractures and skin grafting.

#### ERRORS IN DRESSING BURNS

*Errors in the Selection of a Suitable Burn Remedy.* Unfortunately there is no ideal burn remedy. Tannic acid is toxic to the system<sup>3,4</sup> and locally injurious to tissue cells,<sup>5,6,7</sup> particularly when the burn is kept in a moistened state by repeated applications, jelly bases, infected exudates and bodily discharges.

Sulfa powders and ointments have undoubted value in the treatment of wounds including burns, but they are toxic and their use is fraught with great danger. The blood level attained by absorption of these drugs<sup>8</sup> from burned surfaces is unpredictable and the highest blood levels are usually obtained during the first thirty-six hours at a time when the urinary output is disappointing. The oral or intravenous administration of these drugs appears to be much safer and should be postponed until an adequate urinary output is assured. Their use topically in ointment form is much safer than in crystalline form, for absorption levels are less.

Petroleum jelly is the most universally used burn ointment for it is soothing and does not appear to destroy viable tissue.<sup>5</sup>

*Errors in Débriding Patients.* The extensive débridement of burns was essential to the production of a satisfactory eschar, but now that tanning agents are less desirable so also is débridement. Ultimately we may find that the edema fluid and the overlying burned epidermis are nature's best dressing and that a protective fine mesh-gauze pressure-dressing, without any softening ointment, is most desirable. It has been my experience that the condition of dogs receiving no local treatment following third degree burns of extensive areas of the trunk is clinically superior to those treated with a softening ointment such as petroleum jelly. While the un-

treated animals with the dry burn romp, play, eat well, and behave not unlike normal dogs (i.e., after the first day when narcotics are withheld), the petroleum jelly treated dogs, either with or without dressings, move guardedly, eat poorly, appear depressed and definitely ill. Even after the untreated dogs begin to slough off the burned skin and infection develops along the margins of the eschar, their clinical condition appears better than those with a large stringy, mushy, necrotic, purulent, sloughing surface treated with vaseline. The differences are not unlike those of any dry and moist gangrene.<sup>9</sup>

*Error of Not Providing Adequate Dressings.* Failure to provide adequate dressings is primarily an error in hospital management. In spite of the ever present likelihood of severe burns arriving at a hospital, it is true that even many large hospitals are unprepared to dress these patients properly. One is often confronted with the problem of covering a burn of 40 per cent of the body surface with small vaseline gauze strips which require hours to apply. Every hospital should have several large jars filled with sterile long gauze rolls which may be used to treat any reasonable number of burns. Sterile mechanics' waste and elastic bandages and an abundance of safety pins must be on hand if a good pressure dressing is to be applied quickly and securely.

*Error of Cleansing a Burn too Extensively and Vigorously.* It has been the experience of many that prolonged efforts to débride and cleanse burns are not rewarded by freedom from infection.<sup>10</sup> Some of the poor results in these cases, where all gross dirt has been removed, have occurred, no doubt, from breaks in technic incident to cleansing any form as varied as that of the human body. What is grossly clean is not often microscopically free of bacteria, and what is grossly dirty is not necessarily covered with virulent organisms. The high incidence of infection following prolonged débridement should not lead to negligence of an aseptic technic,

but rather to a greater refinement of technic.

The logical course to follow is that recommended by the U. S. Army:<sup>11</sup> "If the burned area appears clean, no further preparation of the wound is indicated. Small blisters should be left alone, but larger ones may be drained by simple puncture. Gentle washing and débridement are reserved for grossly soiled burns." Smudges of dirt which so often discolor the dermis should be left intact if not readily removed with white soapsuds. Green soap, benzine, ether, scrub brushes, alcohol and special antiseptic solutions destroy a patient's morale and do more harm than good to traumatized tissue.

*Error of Applying a Pressure Dressing too Tightly.* One has but to notice how readily normal skin blanches on gentle pressure, or how quickly blistering and necrosis of skin develops over the heel or sacrum of bedfast patients, to realize the destruction long continued pressure may wreak. Rather than run the risk of destroying all layers of skin in a second degree burn, or of causing gangrene in an extremity, it is wise to err on the side of too little pressure.

*Error of Changing the Original Dressing Prematurely.* Levenson and Lund's emphasis on immobilizing burns in plaster casts<sup>12</sup> would be good if for no other reason than to serve as a brake on the pernicious habit of changing dressings prematurely. Patches of purulent exudate will almost certainly develop beneath the dressing of large burn surfaces within four to five days after injury. If the odor or exudate prompts one to change the original dressing prior to the average healing period of second degree burns (ten to twenty-one days), infection of all unhealed areas may be expected. It is virtually impossible to remove dressings from infected areas without spreading infection to the total area. A dressing done too soon may prove as detrimental as draining an abdominal abscess into the peritoneal cavity.

*Error of Changing Dressings too Frequently.* Changing dressings too often is

not the error of those who treat burns with plaster casts<sup>12</sup> or pressure dressings properly applied, for the care and work involved in their application require the expert attention of a physician. The physician who loses personal contact with the application and removal of the dressing and regards this job as part of the general nursing care, loses a great opportunity to study and help the patient. Each dressing, changed every four to seven days, requires the same meticulous attention as the original one. Too often the burn dressing degenerates into the "laying on" of a saline, boric, or ointment dressing with every eight-hour nursing shift, despite pain and bleeding. With these frequent dressings, the patient becomes a depressed, emaciated skeleton who prefers to die.

#### ERRORS IN FLUID THERAPY

The acutely burned patient requests little beyond the control of pain and thirst. This latter symptom signifies a profoundly rapid alteration of fluid balance and demands prompt treatment. If the victim were a physiologist, he would cry out for immediate and adequate fluid therapy to combat his impending shock. His need for plasma, together with an early nausea and tendency to vomit, invites *intravenous* therapy as most acceptable. Oral administration of food and fluids should, of course, be given according to tolerance, but this route alone should not be relied on at first for the desired high fluid intake and urinary output. While most civilian burns are seen early and can usually be dressed *prior* to starting intravenous fluids, the reverse procedure may be indicated in severe burns in which treatment is delayed. Nothing is so tragic as a beautifully dressed patient in *shock*.

It is fortunate that there remains in the vascular system some substance or body (such as hemoglobin or red cells, respectively) which makes it possible to estimate how much of the fluid component of the blood has been lost following a burn. When contusions, abrasions, lacerations and frac-

tures complicate burns, the additional loss of the red blood cell and its hemoglobin increases the problem of maintaining an optimum blood volume.

Fluid loss from the vascular system to the burned area closely resembles plasma, and plasma remains the basic replacement fluid. The flow of edema back to the vascular system begins about two days following the injury, so that after forty-eight hours the patient literally transfuses himself.

In some severe burns the margin between undertreatment with resulting shock and overtreatment with resulting pulmonary congestion is zero. These deaths force us to recognize that we are neither certain of the best colloids and crystalloids to administer, nor sure of the optimum amounts, routes or rates of their administration.

*Errors of Plasma Therapy.* Unfortunately, many of the best known formulas for estimating the plasma requirements of burns are not actually applied, largely because hematocrit tubes are not widely used. Harkins'<sup>13,14,17</sup> principles of plasma administration are simple and practical: (1) Give 100 cc. of plasma for every point the hematocrit exceeds the normal of 45. (2) If one estimates the average red blood cell count at 5,000,000 and the hemoglobin as 100 per cent (100 per cent equals 15 Gm.), one can approximate the requirements by giving 100 cc. of plasma for every 100,000 red blood cells, or 2 per cent hemoglobin noted above these averages, respectively. (3) 300 cc. of plasma for each Gm. the hemoglobin exceeds the normal of 15 Gm. per 100 cc. (These estimations, as so often pointed out by Harkins, must be made frequently just as insulin requirements of diabetics in coma must be recalculated frequently.) (4) An easy first aid formula to remember is to give 500 cc. (approximately 1 pint) of plasma during the first twelve hours for every 10 per cent of body surface burned. Subsequent calculations may be made by use of formulas previously mentioned.

The bodily requirements of glucose solution and saline are important, too, if the urinary output and acid base balance are to be maintained. Roughly speaking, one-fourth to one-third of all parenteral fluids required during the first two days should be plasma. For patients in shock, relatively more plasma will be required. If no plasma is indicated, glucose and saline should be given (if nausea exists), to maintain an adequate urinary output. To allay any doubts about sufficient plasma administration, a plasma protein estimation is desirable on several occasions during the first two days. A value under 6 Gm./per cent should be corrected with further plasma to maintain the protein level near normal (6.3 to 7.7 Gm./per cent).

The most common error in plasma therapy is the giving of too little plasma during the first forty-eight hours and too much during the ensuing few days. If adequate plasma is given early when burn shock is the most common cause of death, there is little need for it later. Cope<sup>15</sup> has recently emphasized the danger of cardiac decompensation by forcing fluids *after* the first few days.

Another error results from ignorance of how much plasma protein, sodium citrate and water are given in some so-called "plasma transfusions." When blood is mixed with a large volume of dilute sodium citrate-dextrose-buffer solution, the plasma protein content is low. Large quantities of this citrated, watered plasma would be required to satisfy protein requirements. Certainly one could not give appropriate quantities of saline and dextrose solutions in addition to this watered plasma without overburdening the vascular systems of many patients. There is evidence<sup>20</sup> that large quantities of sodium citrate (1.5 Gm. per 10 pounds body weight) are toxic if rapidly administered. Ordinary plasma contains roughly 5 Gm. of sodium citrate per pint; hence 2,000 cc. of citrated plasma approaches dangerous levels for a 150 pound adult. Plasma administered beyond this amount should be given slowly and

cautiously, and in conjunction with other non-citrated fluid therapy.

*Errors in Saline Therapy.* The normal bodily requirements for sodium chloride are from 5 to 10 Gm. per day; and although there are declines in blood chloride levels, and somewhat greater declines in sodium levels in burn cases, there is nothing to suggest that massive doses of normal saline are either necessary or desirable. Although prior to the widespread use of plasma, normal saline was given in excessive quantities, there is still the tendency to rely on it to do what plasma with its high osmotic pressure will do best, i.e., maintain blood volume and prevent shock. Although no attempt should be made to minimize the importance of sodium chloride as an essential body electrolyte, Coller and his colleagues<sup>16</sup> have pointed out its toxic potentialities. Remembering that plasma and any ingested food contains sodium chloride, 1,000 to 1,500 cc. of normal saline daily would seem to be entirely adequate during the first few days. When feasible, the administration of sodium chloride with sodium bicarbonate solution<sup>22</sup> as a "physiologic electrolyte" has been recommended.<sup>17</sup> Additional amounts of this solution can be given by mouth with less fear of chloride intoxication. The exact dosages are still a subject of debate.

*Error of Permitting an Inadequate Urinary Output.* One of the most pertinent questions one can ask in determining the success of the first two days of treatment is, "What were the twenty-four hour urinary outputs?" One of the outstanding characteristics of burns is the meager urinary output, often amounting to only 500 or 600 cc. per day, during the first forty-eight hours. With the kidney having last priority on available fluid, this oliguria is best explained on the basis of an inadequate fluid intake with oligemia, hemoconcentration, hypotension and a reduced renal circulation. It is known that renal blood flow is reduced quite markedly by a slight diminution of arterial blood pressure. To obtain the 1,500 cc. of urine desired of any

surgical patient in twenty-four hours, fluids must be administered early, steadily and in large quantities. When the plasma and saline requirements are satisfied as outlined previously, 5 per cent glucose can be utilized to secure the desired urinary output. Accurate measurement of urinary output on an hour to hour basis by means of an indwelling catheter may provide the best indicator of satisfactory progress or impending shock. At least 60 cc. of urine per hour (1 cc. per minute) will supply the desired amount per day. After the first two days, far larger quantities may be excreted, usually exceeding the fluid intake.

Occasionally, the optimum urinary output can be maintained most readily by adding isotonic sodium bicarbonate (1.3 per cent) or sodium lactate (1.75 per cent) to the fluid therapy (orally or intravenously). These substances are indicated when hemoglobinemia or sulfatherapy threaten renal function or acidosis occurs. Approximately 125 cc. of a one-sixth molar solution (isotonic) has been suggested for a 60 Kg. individual, for every volume per cent the plasma carbon dioxide-combining power is under 55 volumes per cent (normal is approximately 60 vol. per cent<sup>19</sup>). The urine should be kept slightly alkaline or neutral to litmus. When tolerated orally, its administration with normal saline (1 part of normal sodium bicarbonate solution and 2 parts of normal sodium chloride solution, making a "physiologic electrolyte solution") is ideal, for absorption is physiological and there is less danger of overburdening the vascular system.

*Error of Not Giving Enough Whole Blood Transfusions.* Almost invariably a troublesome secondary anemia develops after the initial hemoconcentration phase. Anorexia and its many causes, including infection, almost invariably accompany this hemodilution phase. The strain of an elevated metabolism characteristic of burns, requires that the cardiovascular system be helped as much as possible by whole blood transfusions to maintain the hemoglobin above 80 per cent, the red

blood cell count above 4,000,000, and the plasma proteins above 6 Gm. Failure to heed these requirements leads to retardation of healing, painful spreading decubitus ulcers and prolonged hospitalization, if not death. Recently Harkins believes that whole blood transfusions should be begun the first day, for the idea that they make hemoconcentration worse is no longer accepted.<sup>23</sup>

The absence of a superficial vein in any of the extremities or scalp should not constitute an adequate excuse for failing to give parenteral fluids when necessary. The external jugulars or the femoral veins are almost always available. Their use requires constant supervision by a physician, but this care again emphasizes the fact that severe burns require special attention, and office hours cannot be rigidly maintained if lives are to be saved.

#### ERROR OF FAILING TO MAINTAIN SATISFACTORY NUTRITION

With the patient nauseated and vomiting during the first day or two, it is virtually impossible to supply adequate calories parenterally. During the weeks and months to follow the anorexia and nausea together with fever and an increased metabolism often limit the fulfillment of the caloric requirements of even a bedfast patient. The fat and glycogen stores are depleted and a negative nitrogen balance is the rule.<sup>18,19</sup>

A high caloric, high vitamin, high protein, high carbohydrate diet desirable in these cases is more easily ordered than consumed. In the long run the major portion of the nutritional requirements must be absorbed from the gastrointestinal tract; hence innumerable principles of good burn management must be applied to assure a proper intake. The menu should be specially chosen to conform with the patient's tastes, as well as with his caloric, vitamin and mineral requirements.

Parenteral fluids, while secondary in importance to oral intake, are invaluable. Hydrolyzed casein solutions, such as

amigen, are becoming increasingly popular in providing a positive nitrogen balance and increased plasma protein values. The amino acids supplied by hydrolyzed protein solutions are capable of resynthesis to protein according to bodily needs. Although the clinical improvement of patients so treated is often more gratifying than the improvement in the plasma protein level, the same can be said of plasma transfusions which are far more expensive.

#### ERROR OF FAILING TO SKIN GRAFT EARLY

The Padgett dermatome is the greatest pain killer and life-saver for third degree burns. Those who treat third degree burns should be familiar with its use. One of the saddest spectacles is the presence of exuberant granulations long past optimum grafting time.<sup>21</sup> The waste of time and materials required to dress these wounds indefinitely in the hope that healing from the periphery will occur is secondary to the gruesome, disabling contractures and pain associated with any unnecessary delay in closure of the wound. Harkins<sup>23</sup> states that "as a general rule burns should be grafted at the time of the second change of dressing on about the eighteenth to twenty-first day." This early grafting is made possible by scraping or excising necrotic and granulating tissue of *large* burns down to a firm fibrous bed, and of *small* burns down to normal subcutaneous tissue.

#### SUMMARY

1. The control of shock, infection, malnutrition and scarring are the fundamental objectives of burn treatment. The crescendo of importance of each of these factors varies chronologically, but all depend upon the type of earliest treatment received. The prevention of shock and the control of infection are the chief objectives. The management of dressings to secure the least amount of infection, pain and bleeding will permit early grafting and the minimum of scarring.

2. Contrary to general impression, burned patients need not suffer much pain or become emaciated and exhausted.

3. There is no easy magical treatment for burns permitting one to leave "arm chair" orders. Hard physical work and intelligent management are, and will continue to be necessary, though fads in the treatment of burns come and go.

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# STREPTOMYCIN THERAPY FOR BACTEREMIA\*

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THE demonstration by Colebrook of the clinical success of sulfanilamide in treatment of hemolytic streptococcus septicemia introduced the modern era of effective control of infection by chemical and antibiotic substances. Later studies showed that sulfonamides as a group not only were capable of overcoming streptococcal septicemia, but also they could prevent its development in many cases. As a result, the incidence of this type of infection has been reduced to a relatively small figure. With the widespread use of penicillin since 1943, dramatic recoveries from cases of septicemia due to *Staphylococcus aureus*, viridans streptococci and certain anaerobic streptococci as well as the hemolytic streptococcus, are commonplace. The superiority of penicillin over all other available forms of treatment for infections due to susceptible organisms has been clearly demonstrated and this agent is logically the drug of choice for the therapy of bacteremia.

There still remain a large group of microorganisms, notably the gram-negative bacilli, which are refractory to penicillin and which may, on occasion, invade the bloodstream from a suppurating lesion. Sulfonamides and other therapy for these infections have met with variable success.

Streptomycin is the most promising antibiotic aid presently<sup>1-8</sup> available for the management of gram-negative bacillary infections. According to rapidly accumulating data, the overall results are better than those obtained with the use of the sulfonamides. Furthermore, the effects produced are more rapid and more certain, and serious toxic reactions are fewer and less debilitating. Streptomycin has the additional advantage of influencing sul-

fonamide-resistant and penicillin-resistant organisms, provided they come within the streptomycin-susceptible group. It is bacteriostatic for gram-positive cocci as well as for gram-negative bacilli, but its action is not as powerful as that of penicillin on gram-positive cocci; therefore, its role is that of an alternative agent for those cases not responding to penicillin therapy.

This report summarizes experiences in U. S. Army Hospitals with streptomycin therapy in bacteremias due to gram-negative bacilli and gram-positive cocci. The cases reported are limited to those conditions in which the presence of bacteria in the blood produced definite symptoms. Typhoid fever, undulant fever, and tular-emia are omitted because they represent entities in which bacteremia is part of the disease. Subacute bacterial endocarditis, which is also a separate entity, is included however, because of the importance of this condition, and the paucity of published information<sup>2,6</sup> regarding streptomycin therapy for it.

## ANALYSIS OF STREPTOMYCIN-TREATED BACTEREMIAS

Data on twenty-four cases of bacteremia are tabulated in Charts I, II, and III.

*Etiology.* The causal organisms isolated were as follows:

<i>A. aerogenes</i> .....	5 cases
<i>E. coli</i> .....	5 cases
<i>E. pneumoniae</i> .....	5 cases
<i>Ps. aeruginosa</i> .....	1 case
Coag. pos. hemol. <i>Staph. aureus</i> ..	6 cases
<i>Strep. viridans</i> .....	2 cases

In the sixteen bacteremias due to gram-negative bacilli, the urinary tract was involved in eleven cases, while in the re-

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## STREPTOMYCIN IN BACTEREMIA

CHART I (10 CASES)

Case No.	Causal Organism	Associated Lesion	Days Treated	Total Dosage (Gm.)	Ancillary Therapy	Result
1	<i>A. aerogenes</i>	Post-laminectomy Meningitis	1 (9½ hrs)	0.7	None	Died 9½ hrs. after initial dose, disseminative sepsis.
2	<i>A. aerogenes</i>	Pyonephrosis Ureteral calculi	9	8.6	None	Good after pyelostomy effected drainage. Subsequent ureterostomy followed by clearance of urinary tract infection.
3	<i>A. aerogenes</i>	Pyonephrosis Ureteral calculi	8	18.4	None	Doubtful. Bacteriemia cleared after surgical drainage; organisms in urine became drug-fast.
4	<i>A. aerogenes</i>	Cord bladder, resection of neck	10	10	Sulfadiazine	Good. Bacteriemia cleared but organisms in urine remained; became drug-fast.
5	<i>A. aerogenes</i>	Post-prostatectomy Perivesical cellulitis	9	25.5	Penicillin	Excellent response. Organisms remained in urine until catheter was removed.
6	<i>E. coli</i>	Osteo. rt. tibia Meningitis	16	19	None	Excellent. Blood culture neg. 24 hrs., spinal fluid neg. culture 96 hrs.; temp. fell by crisis
7	<i>E. coli</i>	<i>E. coli</i> meningitis	14	1.95	Penicillin Sulfadiazine	Excellent. Complete recovery in a 2 wks. old infant. Penicillin combined with sulfadiazine ineffective.
8	<i>E. coli</i>	Osteo. rt. ilium	10 & 28	10 & 30	Sulfadiazine Penicillin	No response from 1st course of treatment; 2nd course in conjunction with surgical drainage produced excellent response.
9	<i>E. coli</i>	Urinary tract infection	8	8	Sulfadiazine	Excellent response in a 2 mos. old baby after sulfadiazine failure.
10	<i>E. coli</i>	Pelvic peritonitis Post-abortion	6	1.2	Penicillin	Doubtful. Some clinical improvement.

maining cases the infection arose from sepsis in bone and in the peritoneal cavity.

The *Staphylococcus aureus* bacteremias resulted from sepsis involving various structures, as noted on the chart. In the two *Streptococcus viridans* bacteremias an infected femoral bone graft wound was the focus of localization in one case, while in the other, a subacute bacterial endocarditis followed extraction of a tooth.

**Dosage.** The majority of cases received 1 Gm. or more of streptomycin in divided, intramuscular doses, and treatment was continued for an average period of fourteen days. As indicated in the tables, other

chemotherapy was employed in fourteen of the twenty-four cases before streptomycin, and in all such instances these other chemotherapeutic agents failed to arrest the infection. These drugs were not continued with the institution of streptomycin therapy, except in a few instances.

**Results.** Twenty-two patients recovered and two died. One of these patients was moribund at the time streptomycin therapy was begun, and death occurred nine and one-half hours after the first dose was given, (Case 1, Chart 1). The second death was in a patient with a *Staphylococcus aureus* bacteremia with multiple

## STREPTOMYCIN IN SEPTICEMIA

## CHART II (6 CASES)

Case No.	Causal Organism	Associated Lesion	Days Treated	Total Dosage (Gm.)	Ancillary Therapy	Result
1	K. pneumoniae	Pyelonephritis Renal calculus	37 9	7 6.2	Penicillin	Unsatisfactory. First course produced sterile blood culture temporarily; 2nd course—no response (organisms drug-fast?).
2	K. pneumoniae	Pyelonephritis Renal calculus	8	1	None	Excellent response. Bacteremia followed nephrolithotomy. Temp. normal 8 hrs. after 1st dose.
3	K. pneumoniae	Pyelonephritis Renal calculus Nephrolithotomy	8	1	None	Excellent response. Temp. normal in 48 hrs. Recovery rapid and complete.
4	K. pneumoniae	Pyelonephritis Cord bladder	8	32	None	Good. Temp. subsided by lysis, becoming normal on sixth day of treatment.
5	K. pneumoniae	Pyelonephritis Renal calculi	14	16.8	None	Good. Temp. subsided by lysis with secondary rise. Subsidence after surgical drainage.
6	Ps. aeruginosa	Pyelonephritis Renal calculus Nephrolithotomy	10	11	None	Good. Temp. subsided by lysis. Bacteriology of the urine unaltered.

secondary foci arising from an inguinal abscess, and complicated by ulcerative endocarditis, shown at autopsy (Case 6, Chart III). Death occurred after ten days of streptomycin therapy.

The response to streptomycin therapy in the twenty-two patients who recovered was analyzed on the following: (1) Fever, (2) effect on blood cultures, (3) effect on toxicity, (4) effect on the lesion present before streptomycin therapy, and (5) toxic (drug) reactions.

*Fever.* In nearly every instance the temperature subsided by a step-ladder type of lysis. In some cases mild pyrexia persisted until the course of streptomycin therapy was completed. Whether the fever could be attributed to the drug itself or the absorption of toxic substances from residual foci of infection is conjectural.

*Effect on Blood Cultures.* In most instances the blood was rapidly sterilized of the bacteria. The most rapid clearances of the blood stream were obtained when suppurative lesions were accessible to surgical

interference. When surgical drainage was not instituted, fever and toxemia persisted; the blood stream was occasionally reinfected after withdrawal of streptomycin.

*Effect on Toxicity.* Little clinical evidence of improvement was noted in the usual case until the third or fourth day of therapy. However, in all cases in which recovery occurred, the patient was markedly benefited after the seventh day.

*Effect on the Lesion Present before Streptomycin Therapy.* In the bacteremias originating in the urinary tract, when calculi were present, streptomycin rapidly cleared the blood stream and localized the infection. The continued presence of bacteria in the urine bears witness to the fact that calculi as such are not sterilizable, and bacteria-laden pus cannot be fully evacuated. The organisms in the urine regularly become drug-fast under these circumstances. Pyuria is never eliminated until such time as such obstruction to the free flow of urine is removed. On the other hand, in those bacteremias following sur-

## STREPTOMYCIN IN BACTEREMIA

## CHART III (8 CASES)

Case No.	Causal Organism	Associated Lesion	Days Treated	Total Dosage (Gm.)	Ancillary Therapy	Result
1	Strep. viridans	Femoral bone graft wound	12	29	Penicillin	Excellent. Immediate fall in temp. Graft saved.
2	Strep. viridans	Valvular heart disease	21	79.5	Penicillin	Excellent. Clinical cure. No relapse, six months.
3	Staph. aureus	Inguinal abscess	23	70.3	Penicillin	Good. Organisms penicillin fast.
4	Staph. aureus	Disseminative sepsis Pyodermia	21	19	Sulfadiazine	Excellent. Temp. fell to normal after 48 hrs. treatment. Organisms penicillin resistant.
5	Staph. aureus	Inguinal abscess	5	12	Penicillin	Excellent. Organisms penicillin resistant.
6	Staph. aureus	Endocarditis	10	9	Penicillin	Failure. Patient expired 10th day. Organisms penicillin fast.
7	Staph. aureus	Disseminative sepsis Perivesical abscess	10	10	None	Improved. Organisms remain in urine. Has renal calculi.
8	Staph. aureus	Third degree burns	8	30	Penicillin Bacteriophage	Doubtful. Streptomycin alone and with penicillin gave no results until bacteriophage was given.

gery for obstructive lesions in the urinary tract, streptomycin effectively and rapidly cleared the blood stream and the urinary tract, with complete and dramatic recovery of the patients. The temperature charts on *A. aerogenes* bacteriemias with (Case 3, Fig. 2), and without obstruction (Case 5, Fig. 3), illustrate the importance of instituting surgical drainage whenever it is indicated. Evacuation of pus permits the antibiotic and vascular tissues surrounding the infection to deal with the avascular tissue harboring the residual organisms. Where the lesions were in bone, streptomycin localized the infections, but did not cause them to disappear and surgery was necessary. Adequately drained abscesses resolved without sequellae.

*Toxic Reactions Attributed to Streptomycin.* Two patients had morbilliform rashes with eosinophilia, albuminuria and some pyrexia. In one of these patients (Fig. 1), the administration of calcium gluconate and ephedrine caused the reaction to disappear in spite of the continued administration of streptomycin.

One patient (Case ,2 Chart III) had

vertigo which persisted following the interruption of streptomycin therapy. He had 79.5 Gm. of drug in twenty-one days, and had received penicillin as well during the same period of time. He had no tinnitus and the audiogram was normal. There was complete, bilateral loss of caloric response to ice water. There was no nystagmus. Subjectively, the vertigo showed steady subsidence. When a reaction of this type occurs, streptomycin should no longer be administered. Minor reactions of a histamine-like nature occur in 15 to 20 per cent of the cases. These do not warrant discontinuance of streptomycin therapy.

## GRAM-POSITIVE COCCAL BACTEREMIAS

The series of bacteremias (Chart III) due to gram-positive cocci is important as it represents failures with penicillin in adequate doses for ordinarily sufficient courses of therapy. The data indicate that the use of streptomycin and penicillin simultaneously is warranted if a favorable response to penicillin is not obtained in a reasonable length of time. On the other hand, if *in vitro* testing shows the organism will grow

in concentrations of penicillin which cannot be maintained in the blood, but will show inhibition by streptomycin in concentrations possible by intramuscular injections of this compound, the drug of choice is streptomycin. Our laboratory studies show, (1) an additive effect is obtained from use of subinhibitory concentrations of streptomycin and penicillin, and (2) competitive excretion results in higher drug levels when both agents are parenterally administered simultaneously.

Cases 2 and 3, Chart III illustrate these points. In both patients, the use of the combination of drugs proved a life-saving measure.

**CASE 3, Chart III.** A nineteen-year old male, negro soldier had an abscess of the right groin, presumably staphylococcal, with uncomplicated healing after incision and drainage. He was admitted to an army hospital approximately three weeks later because of cough, fever and myalgia. He ran a septic course with fever up to  $104^{\circ}\text{F}$ . A series of x-ray films revealed pneumonitis in both lung fields, and cavity formation with circumscribed densities. He also developed a right pleural effusion and, later, swelling in the right knee. He received sulfadiazine for five days with no improvement, then 2.4 million units of penicillin in a week with only slight improvement. He became markedly disoriented and was transferred to another army hospital. He remained exceedingly toxic and confused. Here, two blood cultures revealed a heavy growth of hemolytic staphylococcus aureus, coagulase-positive. Repeated x-ray examinations of the lungs showed lesions consistent with pneumonitis with multiple abscess formation. The prognosis appeared grave. Penicillin therapy was continued. In the meantime, susceptibility tests on the staphylococci isolated by blood culture showed the organisms were indifferent to more than 5 units of penicillin per cc., but inhibited by 16 mcgm. of streptomycin per cc. A level of 16 mcgm. is maintained in the blood by intramuscular administration of 0.4 Gm. of streptomycin intramuscularly every four hours. Because the patient was in extremis, streptomycin and penicillin were given in combination. In addition, he received multiple blood trans-



FIG. 1. Diffuse morbilliform rash in a patient following parenteral administration of streptomycin.

fusions for severe anemia. He continued to run a hectic course during the first two weeks of this treatment with average daily temperatures of about  $104^{\circ}\text{F}$ ., which subsequently came down to normal by lysis. However, it is of importance that blood cultures were consistently negative following the institution of streptomycin therapy. There followed a slow and uneventful recovery with clearing of the sensorium and disappearance of toxic phenomena. The combination of drugs in this case were effective when large doses (1.6 million units per day) of penicillin alone, apparently failed.

**CASE 2, Chart III.** A thirty-two-year old white male was apparently in good health until January 3, 1946, at which time he developed unusual fatigue followed by a severe chill. He treated himself with aspirin for the following two days. One month prior to this illness, he had a left molar tooth extracted, and he continued to have pain in spite of a purported relatively easy extraction. On admission to a hospital, he was found to have fever and a systolic murmur, and suspicion of subacute bacterial endocarditis was entertained. Four positive blood cultures for *Streptococcus viridans* confirmed the diagnosis.

Detailed physical examination revealed a somewhat pallid young man with a few scattered petechiae over the chest and back. Blood pressure was 130/72. There was a moderate systolic murmur heard over the apical and pulmonic regions. The white blood count was 8,500 and the red count was 4,300,000 with a hemoglobin of 13.6 Gm. Penicillin sensitivity for the *Streptococcus viridans* indicated that the organism was extremely sensitive.

### A. AEROGENES BACTERIEMIA PYELONEPHRITIS AND PYONEPHROSIS

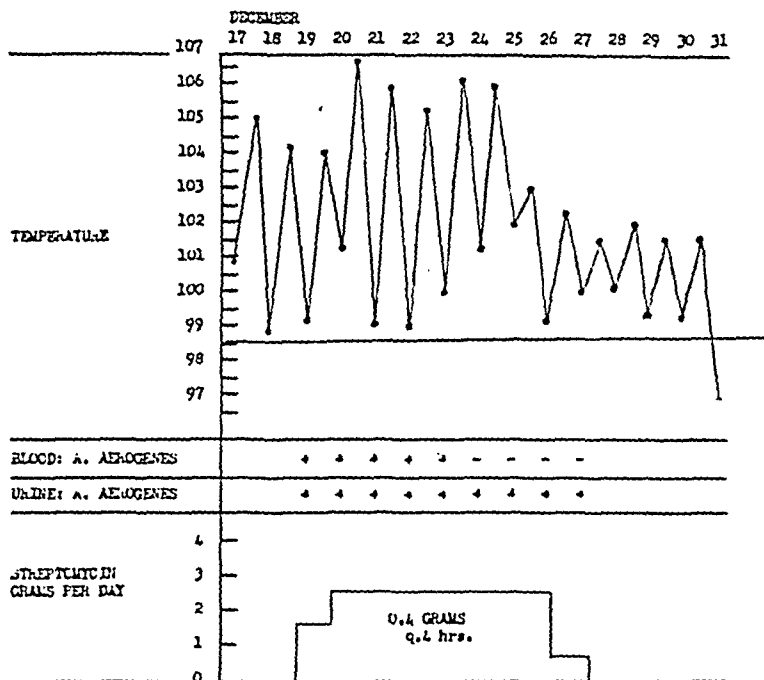


FIG. 2

The patient was started on penicillin, 65,000 units every three hours, and this was continued for five weeks with a total dosage of 18,150,000 units. There was no febrile reaction at any time following the first three days of hospitalization. He had a moderate sensitizing reaction from the penicillin as manifested by itching of the skin but this responded promptly to symptomatic treatment, and disappeared completely on withdrawal of the drug.

On March 1, 1946, he had 0.2° of temperature rise and then a subsequent rise on the following day to 100°F. Blood cultures taken the next two days were again positive for *Streptococcus viridans*. The patient was again placed on penicillin, this time 80,000 units every three hours. On March 19, after eleven days of this therapy, the blood culture was still positive.

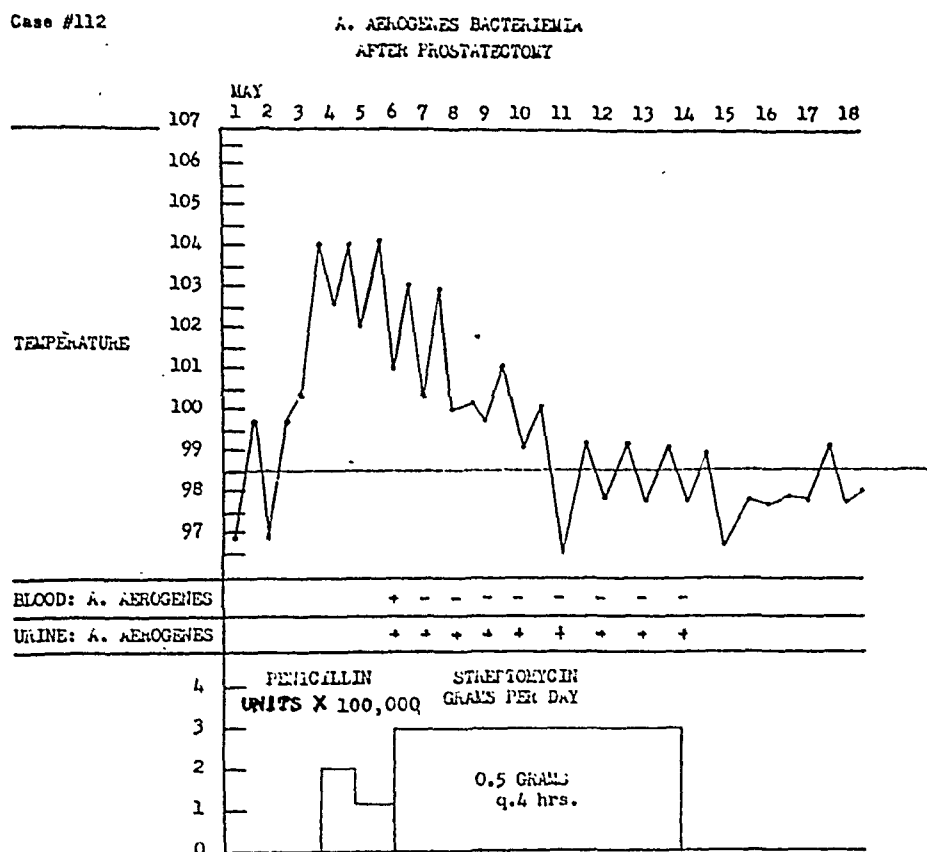
The patient was then transferred to Halloran General Hospital. He continued to run a temperature between normal and a little over 100 degrees and on April 12th, a blood culture was positive for *Streptococcus viridans*. This organism grew luxuriantly in 2.5 units of penicillin. It is not unlikely that the resistance was considerably greater than 2.5 units, which would indicate that even with massive doses of penicillin the outcome would be in doubt.

At this time, the patient had a mild secondary anemia and looked ill. There was a rough systolic murmur at the apex; no definite petechiae were found.

The organism was tested for streptomycin sensitivity, and found to be inhibited by 16 mcgm. of streptomycin per cc. On the strength of the report, it was decided to study the effect of administering streptomycin and penicillin simultaneously. The patient was begun on a course of 0.5 Gm. of streptomycin together with 100,000 units of penicillin every four hours. This regimen was continued for twenty-one days. During the course of treatment the patient's temperature never rose above 99°F. He had no complaints whatever, and blood cultures became and have remained negative. To this writing, five months later, he is up and about and remains symptom-free. As in the preceding case, streptomycin in combination with penicillin appears to have produced a cure.

## COMMENTS AND SUMMARY

Results of therapy with streptomycin in twenty-four cases of bacteremia are presented. Twenty-two patients recovered and two died. Of the twenty-two patients who



recovered, beneficial results attributable to streptomycin therapy were noted in eighteen, while in four others the streptomycin was of questionable value. In the two cases in which death occurred, one died shortly after the initial dose of streptomycin was given. The other death was in a patient with rapidly progressive fulminating staphylococcal pyemia. Death occurred on the tenth day of therapy and was attributed to heart failure. Autopsy confirmed the widespread abscess formation and also revealed an acute ulcerative endocarditis. This patient received both penicillin and streptomycin, although the organisms were penicillin-resistant. The four cases in which streptomycin was of questionable value occurred (1) in a patient (Case 3, Chart 1) in whom drainage of a pyonephritic kidney was inadequate, (2) in a patient (Case 8, Chart 1) with osteomyelitis of the right ileum inadequately drained, who received too small doses of the drug, (3) in a patient (Case 10, Chart 1) with a post-abortion spreading peritonitis

who received far too inadequate amounts of streptomycin, and (4) in a patient (Case 1, Chart 11) who was temporarily benefited, but who relapsed on cessation of therapy. In this instance the dosage was inadequate and the course of therapy too short. When streptomycin was given a second time in larger doses, the organisms were already indifferent to it.

In the eighteen cases in which the administration of streptomycin was considered beneficial, the best results were obtained when the suppurating lesion was amenable to and had the benefit of surgical drainage. In a few instances dramatic results were obtained with surprisingly small amounts of streptomycin, but the most consistent benefits occurred when the daily dosage was in excess of 1 Gm. In practically all cases the blood stream was cleared rapidly of the bacteria.

Analysis of these results makes it apparent that streptomycin therapy in bacteremia can be expected to be successful if: (1) The organisms are susceptible *in*

*vitro*, (2) dosage is adequate, the interval between doses provides bacteriostatic blood levels and the duration of treatment is long enough, (3) surgical drainage of the primary focus is prompt and exact, and (4) due consideration is given to management of the patient as a whole.

In the practical management of bacteremia, it is strongly advised to start chemotherapy as soon as a clinical diagnosis is reasonably certain and blood has been drawn from cultures. The results of the blood culture and subsequent testing of the organisms for susceptibility to the major chemotherapeutic agents will govern the choice and scheme of continued chemotherapy. Despite the fact that our series shows a few cases in which an excellent response was obtained with relatively small amounts of drug, it is recommended that large doses be employed routinely in the beginning of therapy. By such attack, the development of drug-fastness is minimized, and the possibility of maintaining and delivering effective concentrations into relatively avascular foci of infection is enhanced. Therapy should be continued until all evidence of active infection has disappeared and the patient is symptom-free. In the event the organism is proven to be drug-fast to the drug being used, it is imperative to change at once to an alternative chemotherapeutic agent. It is reiterated that, since the mechanism of action of each bacteriostatic agent differs one from the other, drug-fastness to one agent does not imply lack of susceptibility to other chemotherapy.

Our overall experience with modern chemotherapeutic substances has proven beyond doubt that they are only adjuvant to time honored surgical practices. Pus

still must be drained and foreign bodies and necrotic tissue must be removed.

This series of streptomycin-treated bacteremias confirms the fact that the compound rapidly sterilizes the blood stream of susceptible bacteria. However, reinvasion occasionally does occur from undrained foci. Recurrence is roughly proportioned to the dosage administered and to the type and thoroughness of the surgery employed. Analysis of the data shows further that streptomycin in adequate dosages does localize disseminating infection and surgical attack on the primary focus can be made with safety. Streptomycin therapy may be compared to a stream of water which dampens the spreading flame of bacteremia. However, the embers will continue to smoulder until surgery and continued administration of the antibiotic in effective doses have eradicated them.

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# PYRIFORMIS SYNDROME IN RELATION TO SCIATIC PAIN

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**S**CIATICA is a term applied to pain referred along the course of the sciatic nerve and its components. As a rule it is a symptom and not a disease, since it is seldom due to a primary neuritis. The origin of the sciatic pain may be from extrinsic or intrinsic lesions which are often difficult to ascertain. The object of the author is to call attention to a syndrome which can be easily identified as one of the causes of sciatica, and for which a simple operative procedure can give almost miraculous relief.

The term, piriformis syndrome, is applied to that type of sciatica which is due to an abnormal condition of the piriformis muscle, and which is usually traumatic in origin. Necessarily, other pathological conditions of the lumbar, sacral and hip joint areas should be ruled out by examination and x-rays.

The characteristic complaint is pain and tenderness over the lower border of the sacroiliac joint, sacrosciatic notch and piriformis muscle, which often radiates to the hip, causing difficulty in walking; and later in the course of the condition, or at its inception, radiates down the leg along the course of the sciatic nerve. Gluteal atrophy may be present on the affected side depending upon the duration of the symptoms. Often when the patient presents himself the condition has been present for a year or more, and upon questioning, a history of trauma to the buttocks at some time prior to the onset of the illness can usually be elicited. A common type of accident is one in which the feet slip out from under and the individual forcibly strikes the ground in a sitting position. The pain gradually becomes worse over a period of time, and sooner or later radiates down the leg. The

condition is also characterized by acute exacerbations of the pain, brought on by stooping or lifting, which may require long periods of bed rest for relief.

This syndrome is not uncommon, and due to the difficulty in localizing the lesion, no rational management has been adequately considered. Yoemans,<sup>1</sup> in 1928, was the first to refer to the piriformis muscle in relation to sciatic pain. "The piriformis is an abductor and external rotator of the hip and is a flexor of the hip in the act of walking. It arises from the pedicles of the second, third and fourth sacral vertebrae and adjacent portion of the bone lateral to the sacral foramina. It is therefore in contact with the anterior ligament of the sacroiliac joint and the roots of the first, second and third sacral nerves, and its lower border is closely related to the whole trunk of the Sciatic Nerve." Freiberg<sup>2</sup> studied the anatomic relationships of the piriformis muscle in a large number of cadavers, and noted particularly that the piriformis has part of its origin from the capsule of the sacroiliac joint and is the only muscle that bridges that joint. He also noted that it is in close relationship to the sciatic nerve, and in ten per cent of the specimens the nerve passes through the muscle. Grays Anatomy<sup>3</sup> states that it is frequently pierced by the common peroneal division of the sacral nerve, which divides the muscle into two parts.

It can be observed in the cadaver that the piriformis muscle is put on stretch after only a few degrees of leg raising, so in spasm of the muscle or disease, the sciatic nerve and first, second and third sacral nerve roots may be involved. The gluteus maximus muscle overlies the piriformis directly, so compression or injury to this muscle may affect the piriformis.



Freiberg<sup>2</sup> stated that this may be the reason that the Ober<sup>4</sup> operation of incision of the iliotibial band caused relief of sciatic pain in some cases. In abnormality of the piriformis muscle, gluteal atrophy may be observed because of the close proximity and involvement of the first and second sacral nerves. Involvement of the common peroneal nerve in the piriformis may cause the pain to be referred to the outside of the knee behind the head of the fibula.

From the foregoing observations it can easily be seen therefore that any trauma in the sacroiliac or gluteal areas may involve the piriformis muscle and can cause sciatic distribution of the pain, depending on the degree of proximity of the sciatic nerve to the muscle, and the subsequent development of adhesions between them. Yoemans<sup>1</sup> stated that any lesion of the sacroiliac joint may cause inflammatory reaction of the piriformis muscle and its fascia.

The cardinal features of the piriformis syndrome are as follows: (1) A history of trauma to the sacroiliac and gluteal region. This may be difficult to elicit as the patient may not have paid very much attention to the original injury or fall. (2) Pain in the region of the sacroiliac joint, greater sciatic notch and piriformis muscle, extending down the leg and causing difficulty in walking. (3) Acute exacerbations of the chronic pain brought on usually by stooping or lifting, which can be relieved to a great extent by traction on the affected leg. (4) The presence of a palpable sausage-shaped mass over the piriformis muscle during an acute exacerbation of the pain, which is markedly tender to pressure, is almost a pathognomonic sign. (5) A positive Lasègue's sign, and (6) gluteal atrophy may be present depending on the duration of the condition.

#### CASE REPORTS

The following two cases illustrate the complete relief that can be obtained by

section of the piriformis muscle in this type of case:

CASE 1. Mr. E. L., white, male, steel worker, was admitted to the Mercy Hospital with the complaint of pain in the left gluteal region radiating down to his knee and ankle, and inability to walk without pain. In July, 1937, while at work, he was struck by a plank behind the left hip and fell striking his left buttock. He was able to walk immediately, but had slight pain in the region mentioned. For the next two years he had pain in that area, which gradually became worse and caused him to walk with a limp. He also gradually had more frequent exacerbations of the pain brought about by stooping or lifting, which required periods of bed rest. After the first year and a half the pain extended down to his knee and ankle, and he developed a moderate atrophy of the gluteal muscles on the affected side. He was unable to work steadily because of the increasing frequency of attacks of excruciating pain in the left hip and gluteal region radiating down his leg, which would last from two days to two weeks. The attacks would subside more quickly with traction on the leg. All x-rays of the hip, lumbar and sacral areas were negative for pathology, and being a compensation case, he had been treated and examined by a number of reputable surgeons and orthopedists with no permanent relief of his symptoms. On examination he had a positive Lasègue's sign on the affected side, and tenderness over the lower border of the sacroiliac joint, the sacrosiatic notch and piriformis muscle. There was an atrophy of the left gluteal muscles noticeable by observation. During the acute attack a tender sausage like mass was palpable extending from the sacrosiatic notch to the greater trochanter of the femur. The patient was operated upon January 30, 1940, through an incision to be described later. Adhesions present at the juncture of the piriformis muscle and sciatic nerve were broken up with the finger and the piriformis was sectioned partially about one and one half inches from its insertion into the greater trochanter. The patient obtained immediate relief from his pain, was out of bed in four days and went back to work the following week. He has had no pain and has lost no time from

work for the past six years except for an appendectomy in 1941.

CASE II. Mrs. H. G. H., white, female, housewife, was admitted to the Mercy Hospital on October 22, 1940, with the complaint of pain in the right gluteal area radiating down the right leg for the past one and one-half years, during which time she had two episodes of acute exacerbation of the pain, brought on by sudden stooping, which confined her to bed for a month each time. On examination during her third attack she had a positive Lasègue's sign, marked tenderness over the sacrosciatic notch and piriformis muscle, and the suggestion of a sausage shaped mass. She obtained relief in a few days by traction on the leg. On questioning the patient recalled that prior to the onset of her condition her feet had slipped from beneath her on a waxed floor and she had forcibly struck her buttocks when she fell. Her reflexes were normal and no other pathology could be demonstrated. X-rays of the involved areas were negative for pathology. She was operated upon October 23, 1940, and adhesions between the sciatic nerve and piriformis muscle were loosened with the finger and the piriformis was sectioned completely about one and one half inches from the greater trochanter. Complete relief was obtained immediately after the operation and there has been no recurrence of symptoms on the affected side for the past five and one half years.

The sectioning of the piriformis muscle does not interfere with any of the movements at the hip joint and causes no disability as the function is assumed by the gemelli, quadratus femoris, and obturator internus muscles which have a common insertion along the greater trochanter.

At this point it might be well to differentiate this condition from a pathological intervertebral disc at the fourth or fifth lumbar space. The localization of the pain and tenderness in the disc is in the lumbar area. The pain may radiate down one or both legs, while in the piriformis syndrome the radiation of the pain is always confined to the affected side. The pain of a ruptured disc is not relieved by traction, and there is no atrophy of the gluteal muscles. X-rays

will usually demonstrate some narrowing of the intervertebral space in a pathological disc, and contrast media will demonstrate some defect except in the case of a concealed disc. The straight leg raising test is usually positive in a pathological disc rather than the Lasègue's sign, although both may be present.

*Operative Technic.* A line is drawn about two finger breadths below the upper border of the sacrosciatic notch, which can be palpated at the lower border of the sacroiliac joint, to the greater trochanter of the Femur. The incision is made in this line for a distance of five inches or more depending on the size of the individual. An incision in this line does not interfere with weight bearing on sitting. The fascia of the gluteus maximus is incised in the same line and the coarse fibers of the gluteus maximus are separated by blunt dissection down to the piriformis which lies directly beneath the gluteus maximus in this area. A self retaining retractor of the mastoid type is of value in separating the fibers of the gluteus maximus and exposing the piriformis muscle. At the medial border of the piriformis the sciatic nerve will be observed coming out from beneath the lower border of the muscle or through the muscle, and the gluteal vessels and nerve will be seen curving around the muscle from above and below. It is well to separate the sciatic nerve with the finger from any attachments to the piriformis which are usually present in the form of fine adhesions. The piriformis is then picked up about one and one half inches from the greater trochanter and is sectioned, a small portion at a time. When the muscle is sectioned it will be observed to retract for a distance of about two inches, releasing all tension on the structures coming through the sacrosciatic notch. If the piriformis is sectioned about one and one half inches from the greater trochanter the larger vessels are avoided and no bleeding of any moment is encountered. The wound is closed in layers

in the usual manner. The patient is allowed out of bed in four days and the sutures removed in seven days.

The piriformis syndrome is a term applied to an abnormal condition of the piriformis muscle and the symptoms resulting therefrom. The symptoms of pain in the gluteal area and of sciatica are due to the peculiar anatomical relationship of the piriformis muscle and the sciatic nerve and its radicles. If the piriformis muscle is found to be the exciting factor in the cause of the sciatica, then

the simple operation of section of the muscle as described, will bring about immediate and permanent relief of the condition.

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A WOUND which involves the hip-joint from any aspect is likely to be devastating. Large vessels and nerves, more particularly the femoral vessels and the sciatic nerve, often are implicated and, in addition, the femur and the pelvic bones may be shattered.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams and Wilkins Company).

# HYDROGEN ION CONCENTRATION (pH) OF THE VAGINA ASSOCIATED WITH AN ECTROPION OF THE CERVIX (CERVICITIS)\*

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**H**YDROGEN ion concentration of the vagina has been studied in America by Oberst and Plass<sup>1</sup> and Rakoff.<sup>2</sup> Rakoff<sup>2</sup> states, "The middle third of the vagina the acidity tends to be quite constant, and through the cycle ranges from a

TABLE I  
HYDROGEN ION CONCENTRATION (pH) OF VAGINA WITH ECTROPION OF CERVIX (CERVICITIS) IN PREGNANT PATIENTS

No.	Name	Age	Date	PF	AF	LLW	RLW	Ectro- pion pH	Aver- age pH	Additional Data
1.	A. L.	20	5-25-44	4.95	4.79	4.91	4.91	6.47	5.21	Ectropion of cervix, 6 months pregnant
2.	R. C. S.	25	10-4-43	4.70	4.49	4.39	4.22		4.45	5½ months pregnant; ectropion and thick discharge
3.	J. C.	21	3-2-43	4.37	4.05	3.90	3.87		4.05	Ectropion of cervix. postpartum 8 weeks; pregnant
4.	M. L. E.	20	12-10-45	6.18	6.00	5.09	5.22		5.62	Very red ectropion; 7½ months pregnant
5.	C. L. S.	26	6-23-44	5.42	6.00	5.11	5.23		5.44	Ectropion; 2 months pregnant
6.	G. P. W.	24	7-14-44	4.61	5.11	4.99	4.82		4.88	2 months pregnant
7.	J. E. K.	17		4.05	4.18	4.11	4.28	5.15	4.35	Ectropion; 3 months pregnant
				4.90	4.95	4.64	4.65	5.81		

Average pH of all anterior fornices..... 4.95  
Average pH of all posterior fornices..... 4.90  
Average pH of all left lateral walls..... 4.64  
Average pH of all right lateral walls..... 4.65  
Average pH of all ectropions..... 5.81

Total Averages..... 4.99

Oberst and Plass reported hydrogen ion concentrations of the anterior and posterior fornices in normal non-pregnant women during the intermenstrual and menstrual periods; in non-pregnant women with pathological discharge in the intermenstrual and menstrual periods and in pregnant women without and with pathological discharge.

pH of 4.0 to 5.0. Since Rakoff has suggested that the middle third of the vagina tends to be constant, in its hydrogen ion concentrations we have determined the pH of the right and left lateral walls in the middle third of the vagina as well as the anterior and posterior fornices.

The hydrogen ion concentration in the anterior fornix is usually the highest (most

\* From the Department of Gynecology, Research Division, Jefferson Davis Hospital and Baylor University, School of Medicine Houston, Texas. Permission granted by the research committee of Jefferson Davis Hospital, Houston, Texas.

TABLE II  
HYDROGEN ION CONCENTRATION (pH) OF VAGINA WITH ECTROPION OF CERVIX (CERVICITIS) IN  
NON-PREGNANT PATIENTS

No.	Name	Age	Date	Day of Cycle	PF	AF	LLW	RLW	Ectropion pH	Average pH	Additional Data
1.	O. L. D.	22	11-29-43	3	5.72	5.72	5.50	5.39	7.55	5.98	Ectropion menses started today
2.	F. A.	27	12-30-43	16	7.38	7.00	6.10	6.10	7.46	6.81	Ectropion
3.	A. V. F.	41	9-25-43	8	5.62	6.27	5.93	5.78	6.88	6.10	Cervix ectropion. chronic endocervicitis
4.	D. F.	21	10-14-43	90	5.48	5.22	5.55	5.32		5.39	Cervix ectropion
5.	L. G. P.	22	1-26-43		5.19	5.01	4.88	4.76		5.26	Small ectropion post praetrium—5 months
6.	D. L. S.		4-22-43		5.81	5.32	5.37	5.22		5.43	Small ectropion
7.	R. S. W.	42	2-2-43		4.00	4.30	3.60	4.50		4.35	Ectropion; chronic endocervicitis
8.	H. C.	19	12-14-44	5	5.41	4.92	5.08	5.31		5.43	Small ectropion
9.	O. M. H.	29	5-9-44		5.42	5.62	5.23	5.58	5.68	5.51	Large ectropion
10.	E. E. B.	46	12-6-44	24	6.68	5.98	4.78	4.78		5.60	Small ectropion
11.	N. G. C.	34	7-27-44	12	5.48	5.66	5.48	5.43	6.52	5.71	Ectropion
12.	D. W. D.	31	10-13-44	5	6.94	5.81	5.51	5.45		5.93	Ectropion
13.	J. E. G.	23	11-23-44	10	6.41	6.41	5.16	5.24	6.83	6.01	Ectropion and Monilia albicans
14.	M. M. G.	29	2-7-44	17	5.01	5.28	5.72	5.06		5.27	Ectropion
15.	M. E. L.	24	12-29-44	165	5.45	5.43	5.11	5.31	6.99	5.66	Ectropion
16.	C. L. P.	25	5-2-44	9	5.16	5.32	5.02	5.04		5.14	Small ectropion over cervix
17.	F. R.	29	10-31-44	12	6.31	5.68	6.28	5.68	7.35	6.26	Ectropion
18.	C. C.	25	12-22-44	113	4.75	5.36	5.41	5.66		5.30	Large ectropion
19.	G. E. V.	28	10-4-44	20	5.22	6.01	5.86	6.01		5.78	Ectropion
20.	C. E. W.	19	11-11-45	16	5.21	5.19	5.72	5.38		5.38	Ectropion
21.	E. W.	24	12-4-54	23	6.25	5.01	4.96	5.02	6.77	5.60	Ectropion
22.	A. S.	30	5-23-42	51	4.88	4.72	4.91	4.28	5.00	4.74	Ectropion
23.	R. F. O.	27		37	4.12	3.92	4.01	3.97		4.01	Ectropion
					5.56	5.48	5.27	5.23	6.70	5.51	

Average of all anterior fornices. . . . . 5.48

Average of all posterior fornices. . . . . 5.56

Average of all left lateral walls. . . . . 5.27

Average of all right lateral walls. . . . . 5.23

Average of all ectropions. . . . . 6.70

Total Averages. . . . . 5.51

acid) because cervical leukorrhea and vaginal débris usually do not collect in that region.

The hydrogen ion concentration of the posterior fornix is the most unreliable because of the almost ever present cervical leukorrhea with or without an ectropion and due to the fact that the posterior fornix appears to be the "waste basket" for the vagina in that débris and discharge collects in the anatomical pocket in that region.

#### EXPERIMENTAL DATA

The hydrogen ion concentration of thirty consecutive vaginas associated with an ectropion of the cervix was determined. The ectropion surrounded the entire external os. There was also an associated profuse to no cervical leukorrhea present.

The hydrogen ion concentration was determined in the posterior fornix, anterior fornix, left lateral wall and the right lateral wall in the middle third of the vagina and in some cases on the ectropion.

TABLE III

HYDROGEN ION CONCENTRATION (pH) OF VAGINA WITH ECTROPION OF CERVIX (CERVICITIS)

No.	Name	Age	Date	Day of Cycle	PF	ATF	LLW	RLW	Ectropion pH	Average pH	Additional Data
1.	A. L.	20	5-25-44		4.95	4.79	4.91	4.91	6.47	5.21	Ectropion of cervix, 6 months pregnant
2.	O. L. D.	22	11-29-43	3	5.72	5.72	5.50	5.39	7.55	5.98	Ectropion menses started today
3.	F. A.	27	12-30-43	16	7.38	7.00	6.10	6.10	7.46	6.81	Ectropion
4.	A. V. F.	41	9-25-43	8	5.62	6.27	5.93	5.78	6.88	6.10	Cervix ectropion; chronic endocervicitis
5.	D. F.	21	10-14-43	90	5.48	5.22	5.55	5.32		5.39	Cervix ectropion
6.	L. G. P.	22	1-26-43		5.19	5.01	4.88	4.76		5.26	Small ectropion post partum—3 months
7.	D. L. S.		4-22-43		5.81	5.32	5.37	5.22		5.43	Small ectropion
8.	R. C. S.	25	10-4-43		4.70	4.49	4.39	4.22		4.45	5½ months pregnant; ectropion and thick discharge
9.	J. C.	21	3-2-43	47	4.37	4.05	3.90	3.87		4.05	Ectropion of cervix; post-partum 8 weeks pregnant
10.	R. S. W.	42	2-2-43		4.00	4.30	3.60	4.50		4.35	Ectropion; chronic endocervicitis
11.	H. C.	19	12-15-44	5	5.41	4.92	5.08	5.31		5.43	Small ectropion
12.	M. L. E.	20	12-10-45		6.18	6.00	5.09	5.22		5.62	Very red ectropion; 7½ months pregnant
13.	O. M. H.	29	5-9-44		5.42	5.62	5.23	5.58	5.68	5.51	Large ectropion
14.	E. E. B.	46	12-6-44	24	6.68	5.98	4.78	4.78		5.60	Small ectropion
15.	N. G. C.	34	7-27-44	12	5.48	5.66	5.48	5.43	6.52	5.71	Ectropion
16.	D. W. D.	31	10-13-44	5	6.94	5.81	5.51	5.45		5.93	Ectropion
17.	J. E. G.	23	11-23-44	10	6.41	6.41	5.16	5.24	6.83	6.01	Ectropion and Monilia albicans
18.	M. M. G.	29	2-7-44	17	5.01	5.28	5.72	5.06		5.27	Ectropion
19.	M. E. L.	24	12-29-44	165	5.45	5.43	5.11	5.31	6.99	5.66	Ectropion
20.	C. L. P.	25	5-2-44	9	5.16	5.32	5.02	5.04		5.14	Small ectropion over cervix
21.	F. R.	29	10-31-44	12	6.31	5.68	6.28	5.68	7.35	6.26	Ectropion
22.	C. C.	25	12-22-44	113	4.75	5.36	5.41	5.66		5.30	Large ectropion
23.	C. L. S.	26	6-23-44	64	5.42	6.00	5.11	5.23		5.44	Ectropion; 2 months pregnant
24.	G. E. V.	28	10-4-44	30	5.22	6.01	5.86	6.01		5.78	Ectropion
25.	G. P. W.	24	7-14-44	71	4.61	5.11	4.99	4.82		4.88	2 months pregnant
26.	C. E. W.	19	11-11-45	16	5.21	5.19	5.72	5.38		5.38	Ectropion
27.	E. W.	24	12-3-43	23	6.25	5.01	4.96	5.02	6.77	5.60	Ectropion
28.	A. S.	30	5-23-42	51	4.80	4.72	4.91	4.28	5.00	4.74	Ectropion
29.	J. E. K.	17		74	4.05	4.18	4.11	4.28	5.15	4.35	Ectropion; 3 months pregnant
30.	R. F. O.	27		37	4.12	3.92	4.01	3.97		4.01	Ectropion
					5.41	5.33	5.12	5.10	6.56	5.34	

Average pH of all anterior fornices..... 5.33.

Average of all posterior fornices..... 5.41

Average of all left lateral walls..... 5.12

Average of all right lateral walls..... 5.10

Average of Ectropions..... 6.56

Total Averages..... 5.34

TABLE IV  
HYDROGEN ION CONCENTRATION (pH) OF THE VAGINA  
WITH ECTROPION OF THE CERVIX (CERVICITIS)  
COMPARISON OF pH OF FORNICES

No.	Name	Difference between PF and AF	Difference between LLW and RLW	Difference between Ectropion and Average of All Fornices
1.	A. L.	plus 0.16	None	plus 1.58
2.	L. L. D.	plus 0.22	plus 0.11	plus 1.97
3.	F. A.	plus 0.90	None	plus 0.81
4.	A. V. F.	minus 0.65	plus 0.15	plus 0.98
5.	D. F.	plus 0.26	plus 0.23	
6.	L. G. P.	plus 0.18	plus 0.12	
7.	D. L. S.	plus 0.49	plus 0.15	
8.	R. C. S.	plus 0.21	plus 0.17	
9.	J. C. S.	plus 0.32	plus 0.03	
10.	R. S. W.	minus 0.30	minus 0.90	
11.	H. C.	plus 0.49	minus 0.23	
12.	M. L. E.	plus 0.18	minus 0.13	
13.	O. M. H.	minus 0.20	minus 0.35	plus 0.22
14.	E. E. B.	plus 0.88	None	
15.	N. G. C.	minus 0.18	plus 0.05	plus 1.01
16.	D. W. D.	plus 1.13	plus 0.06	
17.	J. E. G.	None	minus 0.08	plus 1.02
18.	M. M. G.	minus 0.27	plus 0.66	
19.	M. E. L.	plus 0.02	minus 0.20	plus 1.66
20.	C. L. P.	minus 0.16	minus 0.02	
21.	F. R.	plus 0.63	plus 0.60	plus 1.36
22.	C. C. R.	minus 0.61	minus 0.25	
23.	C. L. S.	minus 0.58	minus 0.12	
24.	G. E. V.	minus 0.79	minus 0.15	
25.	G. P. W.	minus 0.50	plus 0.17	
26.	C. E. W.	plus 0.02	plus 0.34	
27.	E. W.	plus 1.24	minus 0.06	plus 1.46
28.	A. S.	plus 0.08	plus 0.63	plus 0.32
29.	J. E. K.	minus 0.13	minus 0.17	plus 0.99
30.	R. F. P.	plus 0.20	plus 0.04	

Table I summarizes the findings in the twenty-three consecutive non-pregnant vaginas. Table II summarizes the findings in the seven consecutive pregnant vaginas.

In the entire thirty vaginas the average pH of the posterior fornix was 5.41, anterior fornices, pH 5.33, left lateral walls,

pH 5.16; right lateral walls, pH 5.10. The average pH of all the areas was pH 5.34.

In the twenty-three non-pregnant group the average pH of the posterior fornices was 5.56, of the anterior fornices, pH 5.48; left lateral walls, pH 5.27; right lateral walls pH 5.23. The average pH of all areas was 5.38.

In the group of seven pregnant patients the average pH of the posterior fornices was 4.90, of the anterior fornices, pH 4.95; left lateral walls, pH 4.64; right lateral walls pH 4.65. The average pH of all areas was 4.78. The average pH of the ectropions was 6.56.

### CONCLUSIONS

The hydrogen ion concentration of thirty consecutive vaginas with an associated ectropion of the cervix was determined.

The average pH of anterior fornices was 5.33 of the posterior fornices 5.41 of the right lateral walls 5.10 and of left lateral walls a pH of 5.16.

One might conclude a cervical ectropion may be present in a vagina with normal hydrogen ions, if one accepts the normal pH of the vagina to vary between pH 4.0 and 5.0. This has been observed to be true in cases in which the ectropion appeared to be a "dry type." This has not been our finding in vaginas in which there is a profuse cervical leukorrhea.

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# SIGNIFICANCE OF HYPERURICEMIA IN SURGERY

## AN INTRODUCTION TO CURRENT OBSERVATIONS

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IN a previous study five instances of postoperative gouty arthritis was reported.<sup>1</sup> Investigation of the underlying physiologic disturbance for this complication demonstrated hyperuricemia subsequent to hypoproteinemia to be the major factor. Because of this study our interest concerned the rôle of uric acid in the surgical patient.

As an empirical measure a uric acid level was determined in all patients with a lowered blood plasma. Initially, the majority of patients studied had gastric or rectal cancer. More recently any patient displaying marked protein loss was investigated. This included patients with large draining wounds, peritonitis and empyema. A consistent finding, in the presence of a hypoproteinemia, was an elevation in blood uric acid. Hyperuricemia was similarly revealed in some postoperative patients inadvertently deprived of an adequate protein intake.

An elevated uric acid results because, under the circumstances mentioned, the patient attempts to replenish his protein deficiency through endogenous protein secured from his own body. Clinically this state is revealed in the loss of strength and weight. Chemically it can be demonstrated by an elevated uric acid. The greater the hyperuricemia the more accelerated is the rate of endogenous protein metabolism. The reason for the hyperuricemia is the fact that uric acid is one of the end products of endogenous protein metabolism.

When uric acid is the end product of body purine metabolism, it is called endogenous uric acid. The term endogenous is used to distinguish the uric acid formed from the purines produced in the

course of the digestion of food proteins. Endogenous uric acid is derived from the breakdown of nuclear material found in the muscle tissue and glandular structures.<sup>2</sup> An increase in endogenous uric acid produces an increase in blood uric acid above the normal level (3 mg. per 100 cc. of serum or whole blood). A uric acid elevation above this normal figure indicates a true hyperuricemia.

Additional physiologic processes assist in the production of hyperuricemia. In neoplastic and other debilitating diseases there is a depletion of both protein and body glycogen. The liver supplies the needed glycogen and muscle tissue gives forth the demanded protein. When the liver exhausts its glycogen, hepatic physiology is necessarily impaired. Since it is believed that uric acid destruction is essentially a hepatic function; it can be appreciated that urate destruction is limited in the presence of disturbed liver physiology.<sup>2</sup> In this way a vicious cycle commences with an ever increasing concentration of uric acid in the blood. This vicious cycle is further accentuated when it is known that protein intake accelerates the excretion of uric acid thus lowering its level in the blood.<sup>2</sup> In a surgical patient with a minimal protein intake, the stimulus to uric acid excretion is removed and the hyperuricemia is further increased.

In considering hyperuricemia, other causes for an elevated blood uric acid must be remembered. Primary liver disease may result in a hyperuricemia if the disease process is sufficiently advanced to result in impaired physiology. Since uric acid destruction occurs in the liver, a resulting hyperuricemia is easily understood. Renal



failure is another etiologic factor in the production of hyperuricemia. With renal insufficiency the blood uric acid is one of the first nitrogenous substances to rise. The status of the liver and kidneys can be determined by specific chemical tests directed at evaluating these organs. When the liver and kidneys are not primarily impaired, the pre-existing hypoproteinemia accelerates endogenous purine metabolism. This accelerated endogenous metabolism results in the hyperuricemia. When glycolysis causes an impaired liver function the hyperuricemia is further increased by a diminution in uric acid destruction.

Much emphasis has been placed on hypoproteinemia by many investigators. Our current observation is a step further indicating that hypoproteinemia is a direct cause for an acceleration in endogenous protein metabolism. An end product of this accelerated metabolic state is uric acid which is usually elevated. The significance of hyperuricemia is that it is an indication of the degree of endogenous protein metabolic activity. Thus, a graphic picture of the patients nutritional state can be evaluated via a physiochemical analysis of the blood.

For satisfactory interpretation a plasma protein study must be performed at the same time that a uric acid value is determined. It has been found that hypoproteinemia usually is associated with a hyperuricemia. The lower the protein level, the higher will be the uric acid level. A normal uric acid in the presence of a hypoproteinemia signifies that a sufficient amount of exogenous protein is available to prevent the utilization of endogenous protein. This means that there is sufficient protein available to satisfy the basic requirements of the surgical patient at rest. An intelligent interpretation of serial blood uric acid in association with blood protein determinations will indicate the balance between exogenous and endogenous protein metabolism. Thus, these studies may be employed as a physiochemical prognostic guide to the nutritional state of the surgical patient.

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# END RESULTS OF RUPTURED INTERVERTEBRAL DISCS IN INDUSTRY

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ONE of the most formidable problems which has long faced the medical profession has been the treatment of low back pain. Our failure to treat these conditions adequately has, in part at least, been responsible for the development of such irregular groups as osteopathy and chiropractic. Failure of treatment has been due largely to lack of understanding of the fundamental pathology involved in low back and leg pain. Cognizance of our inefficiency has led the medical profession to accept with enthusiasm any new development which has promised to be of assistance. Fusions of the sacroiliac joint, lumbosacral joint and fasciotomies are but a few that have held popularity, but with the passage of time experience has allocated all to the position they deserve in our armamentarium. Many of these procedures are still of value in selected cases, but have fallen into disrepute largely because they are used promiscuously with little attention paid to the indications as laid down by the authors.

Perhaps the most important development of all has been the recognition of the symptom-complex produced by ruptures of the intervertebral disc. Unlike past developments ruptures of the disc present definite pathology to account for the symptoms for which rational treatment can accordingly be rendered. Recognition of this pathology represents a definite advance in the treatment of the troublesome low back. However, it appears that once again we are running true to form. This condition and its treatment has been accepted with enthusiasm, an enthusiasm which in some instances has largely replaced common sense. At first the diagnosis was based upon definite neurological findings. Of late, however, such findings have not been considered essential to the diagnosis. One neurosurgeon has stated, "The presence of backache with sciatica, worse on coughing and sneezing, makes the diagnosis of ruptured disc unmistakable." It is amazing the number and caliber of men who will accept, without reservation, such a statement as being of diagnostic significance. Orthopedists also are among the enthusiasts and some

believe that the ruptured disc is the cause of most backache. The diagnosis has in some instances been made solely on the presence of a narrowed intervertebral space by x-ray. When the diagnosis is thus made upon such findings or symptoms, it is not surprising that one neurosurgical group was able to remove 479 discs within a nine-month period. In short, rupture of the disc has been widely accepted as the major factor in all cases of back and leg pain. Only with experience will the true importance of this condition be learned.

Any end result study at this time is handicapped by the fact that there is no universal agreement as to what does and what does not constitute a pathological condition within the disc, except in those cases in which there is complete rupture with gross displacement. Part of this confusion in the interpretation is due to our lack of appreciation of the various appearances of the normal disc. It is obvious, therefore, that what might be interpreted by one surgeon as a pathological disc would be looked upon by another as being normal. A concrete example might be given. In one case in our series, operation was performed by a neurosurgeon assisted by two orthopedists. Each man forwarded his view of the operative findings. One orthopedist said the findings were normal; the other stated that hypertrophic arthritis was present, while the neurosurgeon described ruptures of two discs. Another indication of this state of confusion is to be found in the terms used to describe pathology, such as herniated disc, prolapsed, protruding, protruded but not herniated, ruptured, partial rupture, soft, dessicated, occult, concealed disc and a disc which had reduced itself.

The present study is a review of 170 cases in which the patients were operated upon for ruptured disc from 1940 to 1944. They are taken from the files of a large national compensation carrier. A fairly accurate picture of how these cases are handled throughout the country is thus presented. The surgeons, both neurosurgeons and orthopedists, are recognized as outstanding in their communities and many enjoy a national reputation. These cases provide a follow-up from the time of accident until an end result has been reached and afford an excellent opportunity for studying a reasonably large number of cases with a view to determining the following points: (1) In comparing the histories of successful and unsuccessful cases, have any basic errors been committed which might be eliminated. (2) Have there been any differences between the successful and unsuccessful cases in the clinical symptoms or clinical or laboratory findings in such cases? (3) Judged by a practical industrial test of

Mmg. percent	20 or under	20-40	40-60	60-80	80-100	100-150
Ruptured discs 34 cases	2	8	13	7	1	3
No disc 24 cases	0	9	7	5	0	3

FIG. 1. Total protein determination.

fitness for work, what is the average recovery from nucleus pulposis operations as they are practiced throughout this country today in compensation cases? (4) Can anything be contributed that might aid either in the diagnosis or treatment of this condition?

Diagnostic criteria necessary in formulating such a diagnosis varies greatly throughout the country. Some authors claim the diagnosis can be made on a history of either back or leg pain along, or merely on the presence of a narrowed intervertebral space as demonstrated by x-ray. Most surgeons, however, require more substantial evidence. The history in a typical case is that of an acute onset of back pain following strenuous muscular effort such as pulling or pushing, or occasionally as a result of a fall. Usually there is a past history of previous attacks of back pain with or without disability. Leg pain may develop immediately or some time later. Such pain is usually made worse by motion, especially extension. It is aggravated by coughing or sneezing. After some weeks changes in the reflexes appear, as does atrophy of the calf. Subjective and objective sensory disturbances in the form of hypesthesia or paresthesia develop. Many surgeons with a patient exhibiting back and leg pain would not wait for all of the above signs to develop. Most would agree that an individual showing all of the above symptoms and signs would without question have a ruptured intervertebral disc. However, this study would indicate that there is no one sign or symptom, or group of signs or symptoms, that is truly diagnostic.

Elevation of the total protein has been considered diagnostic. However, it occurred as frequently and to the same degree in the cases in which no disc was found as in those with actual rupture. (Fig. 1.)

The question of myelography has been much debated. It has its ardent supporters and opponents. Myelography was performed in 102 of these cases. A defect in the myelogram has usually been considered a diagnostic sign. The myelogram studies in this series, however, were less than 50 per cent accurate. (Fig. 2.) The opaque

A

Material	Defect in column confirmed by operation	No defect in column but disc found	False defect (wrong level)	Disputed findings
Opaque 43 cases	30	4	4	5
Air 10 cases	5	1	2	2

B

Material	Defect in column not confirmed at operation	Negative findings confirmed at operation	Disputed findings
Opaque 34 cases	23	7	4
Air 15 cases	9	5	1

C

Total myelograms	Correct findings	False findings	Disputed or equivocal findings
Opaque 77 cases	48 %	40%	12%
Air 25 cases	40 %	48%	12%

FIG. 2. A, results of myelography where ruptured disc was found; B, results of myelography where no disc was found; C, accuracy of results.

media showed a higher degree of accuracy than air, but the number of false defects was extremely high. This is an important point when one considers the fact that some surgeons completely disregarded their clinical findings when a spinogram showed a defect at a different level. One patient developed pain and numbness in the distribution of the twelfth thoracic dermatome. The myelogram was negative in this area but showed double defects at L<sub>4</sub> and L<sub>5</sub>. Despite the fact that there were no clinical findings or symptoms indicative of a pathological condition at these levels, nevertheless the patient was operated and both discs removed. Failure to find a disc as shown by spinogram resulted in widespread exploration involving in some instances five or six vertebrae. In two instances symptoms indicated nerve root irritation of the fourth lumbar root. The myelogram, however, in this region was negative but showed defects at T<sub>10</sub> and T<sub>11</sub>. Negative findings at these levels resulted in laminectomies from T<sub>10</sub> to L<sub>4</sub> in one case and from T<sub>11</sub> to L<sub>4</sub> in the other.

In this entire series of 170 patients operated upon for rupture of the intervertebral disc there were sixty-seven patients in which no disc was found. This represents 40 per cent of the total and is an adequate indication of the inaccuracy of our diagnostic criteria. The results of operation when no disc was found were poor as compared with those with true disc disorders. Consequently, it was

	Normal	Diminished	Absent
Discs 89 cases	42 (47%)	24 (27%)	23 (26%)
No discs 65 cases	35 (54%)	17 (26%)	13 (20%)

A

	Present	Absent
Discs 49 cases	23 (46%)	26 (54%)
No discs 48 cases	22 (46%)	26 (54%)

B

	Normal	Consistent, objective or subjective	Inconsistent
Discs 82 cases	29 (35%)	48 (58%)	5 (6%)
No discs 62 cases	23 (37%)	27 (43%)	12 (20%)

C

FIG. 3. A, reflexes; B, atrophy; C, sensory changes.

believed that a comparative study of the symptoms and findings in the disc and no disc cases might prove of value.

Definite changes in the reflexes on the involved side were reported in 53 per cent of all disc cases and in 46 per cent of the cases in which no disc was found. Atrophy was reported in 46 per cent of all cases in both the disc and no disc series. Referred pain down the leg on coughing and sneezing was reported with equal frequency in both series. Sensory changes, both objective and subjective, and consistent with nerve root irritation at the diagnosed level were reported in 58 per cent of the disc cases and 43 per cent of the no disc cases. (Fig. 3.)

The high incidence of reflex changes, atrophy and sensory changes, which were found in nearly 50 per cent of the no disc series, is surprising. It is evidence that a positive diagnosis cannot be made even in the presence of such neurological changes. These findings are indicative of nerve root irritation but are not necessarily indicative that such an irritation occurs within the neural canal due to a ruptured intervertebral disc.

Inconsistent sensory findings, we believe, are of importance as they may be the first clue that symptoms are of a functional nature. One of the causes of failure of operation was the development of neurosis. There were ten cases of neurosis in the disc series, or in 10 per cent of the total. There were sixteen cases of neurosis in the no disc series, or 24 per cent of the total. In almost every instance there was ample evidence of such a neurosis before operation. In many

instances in which neurosis was known to exist preoperatively, it was believed that the functional disturbances were based on organic disorders and that by correction of the latter the functional symptoms would disappear. In all instances, however, operation served only to fix the neurosis. In eleven cases the diagnosis of hysteria was made preoperatively by competent men. Hysteria was usually manifested by toe drop, hemiplegia, aphonia and non-anatomic distribution of pain and hypesthesia. In one instance operation was performed by an outstanding neurosurgeon, despite the fact that the patient had been seen preoperatively at different times by seven men, all of national reputation and all of whom had made independent diagnoses of conversion hysteria or psychoneurosis. This surgeon further had forwarded to him copies of all these reports. The patient was eventually operated upon by this man three times with a disastrous result. Our examination, therefore, should include some insight into the patient's personality, and every attempt should be made to rule out symptoms of a functional nature. In the presence of inconsistent sensory findings we believe operation should be postponed.

It is obvious that the diagnosis of ruptured intervertebral disc cannot be easily made. It is our belief, therefore, that the only way to determine the question of whether symptoms are based on operable conditions will be the clinical test of conservative treatment. Ambulatory treatment with the use of belts, braces, infra-red heat or diathermy we believe are inefficient from a diagnostic point of view. No patient should be subjected to operation until he has been given a period of bed rest. Leg traction, manipulation and hot packs will prove beneficial. Only when symptoms persist or recur in spite of adequate conservative treatment, properly supervised and controlled, do we believe operation to be justified. In this series twenty-five patients were operated upon within two months of the date of injury. Most of these were operated upon within the first month, and one patient was operated upon nine days after injury. It was not unusual for operation to be performed within two days of the first neurological examination. In such instances adequate observations could not be made and as a result much unnecessary surgery was performed, as is well indicated in the results. The importance of conservative therapy and of careful observation is evident in the end result of this series.

In the entire series of 170 cases there were five deaths. Three occurred in disc cases and two in no disc cases. Three patients died

	Excellent	Good	Fair	Poor	Bad	Fatal
Discs 103 cases	20	22	26	24	8	3
No discs 67 cases	2	7	17	24	15	2

A

	Excellent	Good	Fair	Poor	Bad
Discs 12 cases	1	1	0	8	2
No disc 6 cases	0	0	0	4	2

B

FIG. 4. A, end results based on symptoms and return to work; B, end results in female patients.

on the operating table, two of anesthesia and one of cardiac dilatation. Two patients died a few days postoperatively of pulmonary embolus.

The remaining cases were classified as follows: (1) *Excellent*—if the patient had no pain and was able to return to any type of employment. (2) *Good*—if the patient had only mild discomfort but was capable of doing all but the heaviest work. (3) *Fair*—if the patient had pain and could do only the lightest type of work such as sedentary work or guard duty. (4) *Poor*—if the patient had persistent pain and failed to return to any type of work. (5) *Bad*—if the patient was worse than before operation and was considered to be totally and permanently disabled.

The end results are shown in Figure 4. Thus it can be seen that the end results of operation in compensation cases are not good. The results are definitely better when a ruptured disc is found to be the actual cause of the symptoms. However, only 20 per cent of these cases remained symptom-free and were capable of return to heavy work. A summary of the end results of the entire series shows that 13 per cent are excellent, 17 per cent good and 25 per cent are considered fair. The remaining 45 per cent continue to have symptoms and have never returned to work. In all fairness it should be noted that we have included in the disc series all cases in which a disc is said to have been found. There are several cases in which we had reason to question the findings. For example, it was not uncommon for the surgeon to report finding a ruptured disc at the preoperatively diagnosed level. Some doubt, however, was cast on these findings when postoperative x-rays showed extensive laminectomies both above and below this level. In all probability the end result of the disc



cases would be better if all questionable cases could be eliminated. The poor results of the no disc series is ample evidence that conservative treatment should be followed first and that operation be performed only after careful observation. This is particularly true in the case of women, in whom neuroses appear to play a prominent part.

The great majority of the ruptures were found to be either at the fourth or fifth lumbar. In the entire series of 103 cases fifty were found at the fourth lumbar, forty at the fifth lumbar, and two double discs were found at both the fourth and fifth lumbar. Three cases were reported as occurring at the third lumbar. In eight cases the exact level was not given. In the no disc cases numerous conditions were found at operation to which the symptoms were attributed. In twenty-seven cases nerve root irritation was said to have been due to hypertrophy of the ligamentum flavum, in five cases to localized arachnoiditis, in two cases to engorged epidural veins. Arthritis and extradural adhesions were among the other causes.

There were few complications. However, those that occurred were serious and contributed markedly to disability. Sepsis occurred in nine cases, one resulting in osteomyelitis of the spine. Phlebitis occurred in four cases. Headache, attributed to lipiodol in the ventricles, occurred in one case. Trophic ulcers occurred in one case. Toe drop occurred in six cases, four cases preoperatively and two cases postoperatively. In the preoperative cases two were diagnosed as being due to hysteria and both were worse following operation, although discs were said to have been removed. The other two cases cleared up following operation, although in one case no disc was found.

In two cases toe drop came on immediately following operation; both persisted resulting in disability. One of these cases already mentioned was operated upon at the fourth and fifth lumbar on the myelogram findings, although the symptoms were entirely localized, in the dorsal area.

There were three cases of paralysis of the quadriceps. All occurred postoperatively and were directly due to surgery; two following section of the post-root of the third lumbar nerve for relief of pain and one following extensive laminectomy. All patients are totally disabled. Considering the number of patients operated upon and the number of surgeons involved, the total number of complications is not great, though some of them could definitely have been avoided.

Persistence of symptoms led to reoperation in forty-one cases. These were almost equally divided between the two groups, that is,

	Excellent	Good	Fair	Poor	Bad	Fatal	Pseudarthrosis	Refusions
Discs 21 cases	2	3	5	6	5	0	5	4
No discs 18 cases	2	1	6	4	4	1	6	5

A

	Excellent	Good	Fair	Poor	Bad	Fatal	Pseudarthrosis	Refusions
Discs 8 cases	0	2	4	1	1	0	1	0
No disc 7 cases	0	1	2	2	2	0	0	0

B

FIG. 5. Result of fusion operations: A, primary fusions; B, secondary fusions.

20 per cent of the disc cases and 30 per cent of the no disc cases were reoperated. Of the disc cases seventeen patients were operated upon a second time, while three patients were operated upon a third time. In the no disc series fourteen patients were operated upon twice, five patients three times, and two patients five times. In all instances reoperation was in the form of re-exploration, fusion or refusion. In one case in which four operations failed to give relief, chordotomy was performed. This, too, failed. This high percentage of reoperation is evidence of the inadequacy of our treatment to date.

Primary fusions were performed on twenty-one cases of ruptured disc. The results of this procedure were as follows: two excellent, three good, five fair, six poor, and five bad. Five patients developed pseudarthrosis, four of which were refused at a later date. In eight cases of ruptured discs fusion was performed at a secondary operation. The results of these secondary operations were two good, four fair, one poor and one bad. One patient developed pseudarthrosis.

In the no disc group primary fusions were performed in eighteen cases. The results of this group were two excellent, one good, six fair, four poor, four bad and one fatal. There were six cases of pseudarthrosis five of which have been refused. (Fig. 5.)

Secondary fusions were performed in seven cases with results as follows: one good, two fair, two poor and two bad.

Taken as a whole the results of fusion are not particularly encouraging. Of the thirty-nine primary fusions performed, nineteen patients, or only 50 per cent, were able to return to some form of work. Of the fifteen cases of secondary fusion nine cases, or 60 per cent, were able to return to some form of work. The incidence of pseudarthrosis in both primary and secondary fusions was 22 per cent. Such a high percentage of failures as a result of fusion was largely due to faulty technic, and here at least is an opportunity to improve our results. If the same principles of rigid fixation as applied to

fracture treatment were applied to the fusion operation, the results would probably be much better. Fixation of the facets by metal screws offer one method of adequate immobilization.

Orthopedic surgeons as a rule were inclined to perform primary fusions, while most neurosurgeons were opposed to such a procedure. In cases of long history of backache simple removal of the disc can hardly be expected to relieve both back and leg pain. In such cases back pain is probably the result of instability in the low back due to abnormalities in the facets. Such abnormalities produce abnormal stress and strain in the lumbosacral region. As a result the articular cartilage of the facets undergoes degeneration. As the stress and strain forces are transmitted to the disc, this, too, in time undergoes degeneration. With the exception of the cases produced by violent trauma, rupture of the disc must first be preceded by degeneration of the disc. Rupture of the disc is, therefore, the result of instability with resultant degeneration over a period of time and seldom the result of a single accident. In such unstable backs, pain will persist after removal of a disc. Such instability should be recognized at the time of operation and, if found, primary fusion should be performed. We do not believe it is wise to postpone fusion and to hold it in reserve should symptoms persist or recur. Many patients will not subject themselves to secondary operations and the results when performed are not too good. This is largely due to the development of mental depression or a neurosis as a result of persistent pain unrelieved by the first operation. We are of the opinion, both as a result of this series and of our own private practice, that primary fusion should be performed more frequently. The caliber of fusion as performed throughout the country must be markedly improved, however, to affect the result materially. For the best results we believe that both the neurosurgeon and the orthopedist should be present at operation.

Up to the present we have been concerned chiefly with the poor results due either to error in diagnosis or to lack of conservative treatment or observation. In many instances poor results were due either to faulty technic or to poor surgical judgment. In a high percentage of bad results well qualified consultants had disagreed with the diagnosis and opposed operation, indicating that many failures were possibly due more to poor surgical judgment or poor technic than to any other factor.

Some specific instances of poor technic or questionable surgical judgment may be cited. One failure of fusion occurred because it was

performed between the fourth and fifth lumbar and first sacral, but on one side only. Stability from such a procedure could hardly be expected. In two instances exploration and fusion were performed at the wrong level, resulting in unsuccessful secondary exploration. In one instance a total laminectomy of the fourth lumbar was performed. In addition the facets between third and fourth lumbar were completely removed bilaterally. The patient described the feeling postoperatively "as though my back were uncoupled." This patient developed a permanently paralyzed quadriceps. There was a tendency on the part of some surgeons to perform widespread laminectomies. In some instances the entire lumbar spine was opened up. This procedure was followed in a few cases by intradural exploration of the entire area. In addition, in two cases the third lumbar root was severed to relieve pain when the above procedure failed to demonstrate any pathological condition. Although presumably only the posterior root was severed, both cases developed atrophy of the quadriceps with an absent knee jerk. This resulted in marked instability of gait, sufficient in both instances to render the patient totally disabled. Such extensive surgery, in view of negative findings, must be classified as radical and ill advised.

Perhaps one of the chief causes of persistent back pain is the almost universal tendency to decompress the nerve roots by enlarging the laminectomy laterally. In so doing the facets are often partially or completely destroyed. Unless the facets are then fused the resultant scar and callus formation produce traumatic arthritis with resultant back pain. If it is not the surgeon's intention to perform a fusion these joints must not be injured.

The comparative end results of the disc and no disc group are reflected in the costs. As of January, 1946, the average total cost, including medical expenses and compensation, of 103 disc cases has been \$2,902, while that of the sixty-seven no disc group has been \$3,990. However two to six years after injury thirty-six patients, or 35 per cent of the disc cases, are still on compensation, while thirty-five patients, or 52 per cent of the no disc cases, are still on compensation. It would thus appear that operation has not only failed to relieve discomfort but has also failed to return these individuals to work.

#### SUMMARY

We are well aware of the fact that the average compensation case is not the best possible material for a favorable end result study.

The desire for financial reimbursement for injuries received is of paramount importance to many individuals. That this fact has definitely influenced the end result cannot be denied. However, the period from 1940 to 1944 was one of intense industrial activity brought on by the war. High wages were to be had even by patients who had partial disability. As a result, the results during this period are probably better than they would be in normal times. Nevertheless, the end results of operation for rupture of the intervertebral disc in compensation cases as performed throughout the country from 1940 to 1944 leave much to be desired. Only 13 per cent are symptom-free and capable of performing heavy laborious work. Seventeen per cent have some persistent symptoms but are capable of doing all but the heaviest type of work. Twenty-five per cent have pain and are able to perform only light work. Classed as bad results, 42 per cent continue to have pain and have never returned to any type of work. There was a 3 per cent mortality. The comparison of the 42 per cent bad results against the 30 per cent good results is striking.

The percentage of error in diagnosis with present diagnostic criteria is about 40 per cent.

Secondary operations were required in 24 per cent of all cases.

#### CONCLUSIONS

We believe that better results could be obtained; first, by the use of adequate conservative treatment before any operative procedure is considered; second, by more careful observation, especially of the mental make-up of the individual; third, the adoption of primary fusion in cases of definite instability; fourth, by the application of the principles of rigid fixation to the fusion operation; fifth, by the preservation of the facets if no fusion is contemplated; sixth, by the application of common sense in exploratory laminectomies.

We thank the Liberty Mutual Insurance Company of Boston, for permission to review the files. We also thank Mr. Frank Falvey of the home office of the company for his assistance in the compilation of the data.

#### DISCUSSION

ROBERT L. RHODES (Augusta, Georgia): Mr. President and gentlemen, I wish to refer to a discussion that I presented before the Southern Surgical Association, of a paper by Dr. Albert Key a year and a half ago, relative to these cases with negative findings. A great number of these low back-aches are nutritional problems and are not due to injuries.

Down our way Dr. Sydenstriker has taken quite a leading part in the discussions and studies of nutritional problems. We have applied that to many of these back injury cases, and when we consider that neuritis in general, of all the peripheral nerves has been markedly increased during the past five years, along with problems of nutrition, poorly balanced diet, very poor food quality that we are all eating today, that is equally as true in industry as it is in private practice, it is more than coincidence.

A great many of these cases, I think, come under that group, and I reported at that time over 100 cases, none of whom had been operated upon. I reported also several cases in which the patients had been operated upon and who continued to suffer just as much or more than they had before the operation.

Using a Pacific Coast terminology, many of those people's lesions, neuritis in general, developed under that condition or affliction known as an acid-ash acidosis, or "a coke and a sandwich" for food instead of a balanced diet. Therefore, there is a marked diminution particularly of the B group vitamins; and if a balanced diet, an abundance of fluids and large doses of the B group of vitamins in particular are used, many of these cases will clear up. Fifty to 100 mg. of thiamin and nicotinic acid, 2 or 3 mg. of riboflavin, three times a day, in a relatively short period of time will show improvement in some of this group who are associated with negative findings. If it is a malnutritional problem, I would say almost in thirty days' time one is going to see results.

It has been a pleasure to save more than one from the knife and from mutilating operations by that procedure.

J. HUBER WAGNER (Pittsburgh): Mr. President and gentlemen, I just could not sit still and have this paper go by without saying a word in its favor.

This to me has been the best survey of this procedure that I have ever had the pleasure of hearing. It was made without the personal element, I am sure; it gave us a picture of the things that are being done on these discs throughout the country. The results speak for themselves. They are horribly poor.

I believe the time has come when some Society must speak up against this procedure, not necessarily absolutely against it, but certainly toward conservatism. We have a large service in Pittsburgh in which we have many back cases, with referred sciatic involvement and referred pain. Last year we had over 100 hospitalized, and of those we operated upon two after consultation by a neurosurgeon and a neurologist confirming the diagnosis of inter-disc rupture. In one fortunately, we found a disc with relief; in the other we found no disc at the third, fourth or fifth interspace.

We are conservative. It has been our contention that though there is such an entity, it is not as frequently found as the general neurosurgeon and orthopedic surgeon would have one believe. There have been too many

people unnecessarily operated upon; and unless there is honest opposition, this will continue. However, we see the swing to the right. I hope it continues. I think our slogan should be, "Operation in the last instance instead of the first."

Again I want to congratulate Dr. Aitken on the excellency of his timely paper.

THOMAS B. QUIGLEY (Boston): I would like to add my congratulations to Dr. Aitken for a splendid review. My own interest in this subject was brought about by a personal experience, and illustrates a small group of disc cases that have no back pain, whose pain is pure sciatica.

In the European theater, with the vigorous training which preceded the invasion of the continent, we saw a great many back injuries of one sort or another, and a small group who presented only sciatica, and almost invariably objective as well as the usual subjective changes. The few that were operated on in that theater seemed to do very well. I wonder if he would care to comment on that aspect of this problem.

Another aspect of the matter that fits in with Dr. Aitken's observation is that officers almost invariably did better than enlisted men.

Another point which always comes up in any disc discussion is the so-called hidden disc. I wonder if Dr. Aitken investigated that aspect of the problem in his survey.

HOMER STRYKER (Kalamazoo, Michigan): About two years ago I heard a paper or a résumé by an insurance company on all the discs done in the Chicago area, and briefly their results were in about 50 per cent of what they considered good. Perhaps 60 per cent they would consider passing. So I decided to concentrate from that time on in eliminating the other 40 per cent from my operative cases, thereby hitting 100 per cent good results.

A few of the things we have done toward this end is not to operate on a patient who did not have some sign (I think the most reliable one is the anesthesia conforming to the area of the fourth or fifth root) of nerve root pressure. The other type we have tried to eliminate is any patient who had a neuropsychiatric tendency; you have to analyze those yourself.

The other criterion is never to operate on one who has not had a good, long period of conservative treatment consisting of at least ten days to two weeks of complete bed rest, absolute bed rest. We never operate on them as long as we can keep them working without operating on them. Some patients will get better.

Also, we are always leery of the case that has symptoms and signs but has a hollow back, that has an increased lumbar concavity. I operated upon one a week or so ago who had all the signs of a disc, but with a hollow back, and we found a cystic tumor of the cauda equina about the size of a thumb.

I also want to bring one or two other cases to you that we have run across, which might be of some interest. One patient developed typical disc

symptoms while in bed following a collapse of one lung for tuberculosis. We suspected tuberculosis of the spine. The x-rays were negative, but he had sciatic pain which required morphine. He had atrophy of the leg, loss of sensation and all the signs. So we went in and found a tuberculous disintegration of the disc, and it did have some bony destruction on one side of the vertebra, but not that would as yet show up in an x-ray. It had a nice disc which burst open and gushed out pus. That particular case developed an embolus in his good lung on the sixth day, and we happen to have the pathological specimen showing it.

We must not forget the possibility of these cord tumors and these x-ray signs in such cases.

ALEXANDER P. AITKEN (closing): I wish to thank the discussers for their comments. I agree with practically everything that has been said. There is little doubt that even at the present time we know little about the fundamental causes of back and leg pain. The mechanical disturbances in the facets play a large part but they probably do not account for all back pain. Back pain, of course, can be due to postural disturbances and in some instances might be due to nutritional disturbances as mentioned. Much backache may be due to flabby weak musculature.

In this series many individuals who developed back pain had not worked for a long period of time. They returned to work, attracted by the high wages being paid. Such individuals not accustomed to heavy work, of course, were more prone to injury. The period from 1940 to 1944 was one of intense industrial activity and many individuals unquestionably returned to work, lured by high wages despite the fact that they continued to have discomfort following operation. If the same type of surgery is performed in normal times, we can be sure that our end results will not be as good as those presented.

We have tried to make this study impersonal and have not included any of our own cases. We have attempted to find what the indications for surgery are throughout the country.

Dr. Quigley has referred to the cases he saw in Europe. His cases were subjected to more violent trauma. I do not doubt that this trauma was sufficiently violent to produce primary ruptures as a direct result of a single trauma.

A good deal has been said about hidden discs. In general, the more popular the surgeon or his institution, and the more writing and talking that was done by this surgeon or his group, the more apt were they to find hidden discs. It was not uncommon at re-operation for hidden discs to be found, but these were always found at an interspace higher than the one operated.

I do not believe that there is any one diagnostic sign. Anesthesia has been given as a diagnostic sign. However, in instances of meralgia paresthetica we have hypesthesia and even anesthesia due entirely to involve-



ment of the lateral cutaneous nerve of the thigh. One must be sure that he is not dealing with this condition in cases of back and leg pain.

I would not consider ten days' bed rest adequate treatment. Before any patient is subjected to operation he should be given an adequate period of bed rest and every opportunity to quiet down. I do not believe a period of six weeks is too long a time.

We must bear in mind that the ruptured intervertebral disc is a real clinical entity. It produces definite symptoms and causes real disability.

Because the statistics as given in this paper would indicate that the end results are not good following operation, we must bear in mind that the poor results are largely because of errors in diagnosis and in failure to use good surgical judgment. Far better results can be obtained and many more patients given permanent relief from this condition if we will only be a little more conservative in our treatment and a little less willing to operate until all other measures have failed. There is no question but what too much ill advised surgery has been performed. In time and with experience we will learn how to diagnose this condition more accurately and how to treat it surgically with better results.



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# Case Reports

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## PREGNANCY IN A RUDIMENTARY HORN OF THE UTERUS\*

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ALTHOUGH much has been written on the subject of true double uterus, there has been, in recent years, a paucity of case reports on rudimentary horn of the uterus. Miller in 1922, reviewed fifty-four cases of uterus didelphys and Schauffler in 1941, discussed pregnancy in the double uterus in eleven patients. In 1943, Taylor reported on pregnancy and the double uterus in eight cases. In the period from November, 1945 to January, 1946, three separate case reports on true double uterus appeared in one medical journal alone, testifying to the abundance of literature on this abnormality. In comparison, pregnancy in a rudimentary horn of the uterus has been infrequently reported. Mulsow, in 1945, in an attempt to review the American and English literature on the subject, was able to study the records of only nine case reports on pregnancy in a rudimentary uterine horn, since Beckmann's review in 1911. Mulsow's review did not include a case report from India, by Waters in 1944.

Since true double uterus is rare (occurring once in 1,500 obstetric and once in 2,000 gynecologic cases) it is natural that one of its variants must be even more infrequent. However, the complete duplex anomaly gives rise to definite signs and symptoms, so that it is correctly diagnosed in a greater percentage of cases than is the enigmatic rudimentary horn. Uterus didelphys is many times suspected apart from pregnancy so that a diagnosis may be made with the aid of metal sounds and uterosalpingograms, while a rudimentary horn may not be suspected unless it is the site of a

gestation, which contraindicates the use of these diagnostic methods. It is significant that in all cases reported, the rudimentary horn contained a pregnancy, and in each instance the abnormality was diagnosed at operation or at autopsy. It seems probable therefore that many women go through a normal life having a rudimentary uterine horn which does not become the site of a pregnancy and is therefore never discovered. The reasons for lack of correct preoperative diagnosis in cases of rudimentary uterine horn become evident when a detailed comparison of its diagnostic features is made with those of true double uterus.

Early diagnosis of double uterus is missed more often than it is made, according to Schauffler. This fact, at first glance, seems unjustified since (theoretically) the concomitant existence of developmental abnormalities of the vagina and cervix gives rise to many warning signals pointing to the presence of a double uterus. Miller states that the presence of a septate vagina and double cervix may cause the patient to seek medical attention at one of three periods of her life. "First at adolescence, when some menstrual disturbance brings the patient for examination and the anomaly is discovered. Second, at the time of marriage because of dysparunia or some other marital difficulty. Third, it may be discovered by the physician during pregnancy at the time of antepartum examination or during labor." Actually, a consideration of the case reports on true double uterus reveals that menstrual irregularities are not common, dysparunia often

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FIG. 1. Uterus bicornis unilatero rudimentarius. "Of great clinical importance, because pregnancy may occur in the rudimentary horn, and such an accident is worse than ectopic gestation, with which it is usually confounded." (Drawing modified from DeLee to show a pregnancy in the rudimentary horn.)

self-adjusted, and vaginal septa torn or altered by a previous apparently normal child-birth. For these reasons, a correct diagnosis is often not made until some complication of labor occurs and cesarean section is done.

Since there is a very low percentage of initially correct diagnosis made in cases of true double uterus, it is evident why the diagnosis of pregnancy in a rudimentary horn is not made before laparotomy is performed. The patient having a rudimentary horn, usually has a normal vagina and cervix, and therefore offers no history of menstrual disturbances or dysparunia, and in addition the important vaginal clue is not found at pelvic examination. The diagnosis must then be based on a suspicion of a very rare condition when practically no suspecting signs or symptoms are present. The only sign pointing to the true condition is one which, at best, would be difficult to be sure of, in differentiating an ectopic pregnancy, namely, the location of the round ligament in relation to the gestation sac. As stated by De Lee, most cases of pregnancy in a rudimentary horn are diagnosed after the abdomen is opened for a supposed extrauterine pregnancy, and this was true of the case reported below.

#### CASE REPORT

Mrs. M. B., a white housewife, aged twenty-six, para II, gravida III, was referred to Kadlec Hospital by her family physician on March 10, 1946, with the working diagnosis of "left ectopic pregnancy."

Good health had been enjoyed until February 25, 1946, when sudden sharp left lower quadrant pain radiating to the pubic region occurred. Dizziness and weakness accompanied the pain but there was no frank syncope. A dull ache, aggravated by motion, persisted in the left lower abdomen. Any attempt to stand or walk initiated a "swimming dizziness" and caused sharp abdominal pain so that continuous bed rest was resorted to. On several occasions, nausea, vomiting and frequency of urination occurred. The latter symptoms were attributed by the patient to an early pregnancy as there had been amenorrhea since January 15, 1946. No vaginal bleeding or spotting had been noted since the last menstrual period.

The past history was significant in that two normal pregnancies had occurred with uncomplicated deliveries at term, 9 and 7 years before the present hospital admission. Regular menstrual periods had started at age thirteen and were interrupted only by the two pregnancies.

Physical examination disclosed a well-developed, well-nourished female, somewhat pale and in mild abdominal distress. The patient's temperature was 98.6°F., pulse 88, respiration 22 and blood pressure 110/64. Examination of



FIG. 2. Specimen removed at operation showing fetus, placental membranes, rudimentary horn, oviduct and stump of left round ligament (actual size).

the head, neck, heart and lungs revealed no relevant abnormalities. The abdomen was symmetrical but on palpation there was a fullness in the left lower quadrant with sharp tenderness in the same area. There was no blueing of the umbilicus and shifting dullness was not present. Pelvic examination revealed a multiparous introitus and a normal vagina with no evidence of septa or partition. There was no evidence of inflammation about the urethra or Skene's ducts. The cervix was single, soft, patulous, normal in position and tender on motion. The corpus was felt to be anterior, pulled or pushed to the right side of the pelvis, symmetrical, slightly enlarged, mobile and mildly tender. The right tube and ovary were not palpated. On the left side a mass about 6 cm. in diameter was palpated, which was symmetrical, soft, mobile and tender. Bimanual and rectovaginal examination confirmed the above findings and added the information that the mass dipped into the left cul-de-sac.

An analysis of the urine was normal. The hemoglobin was 11 Gm., red blood count 3,780,000 and white blood count 14,400. A vaginal smear and culture was negative for gonococcus. The blood type was B, and Rh determination proved negative.

A diagnosis of ectopic gestation was made and immediate operation advised. Since the hospital laboratory contained a file of Rh negative donors for each group, two compatible donors were soon located and held in reserve.

Under spinal anesthesia supplemented by intravenous pentothal sodium, a mid-line, infra-

umbilical incision was made and the abdomen opened in layers. The pelvis was of a deep funnel type with a narrow pubic arch so that gaining adequate exposure was difficult. There was no free fluid or blood in the peritoneal cavity. The uterus was pushed to the right, was symmetrical and enlarged to the size of a 6 weeks gestation. The right tube and ovary were normal. An elliptical mass, approximately 6 cm. in diameter, was seen in the left adnexal region. It was soft, bluish-purple in color, and had the appearance of a tubal pregnancy which had ruptured between the leaves of the left broad ligament. Closer inspection revealed the round ligament and the fallopian tube proceeding from the lateral border of the mass. The left ovary was posterior to the mass and contained an active corpus luteum. As the dissection proceeded, it became clear that a pregnant rudimentary horn joined the main cervix just above the level of the internal os, by a thick fibrous band of tissue. (Some idea of the type and location of the mass and related structures may be formed from the schematic drawing (Fig. 1) modified from De Lee.) The proximal attachment of the rudimentary horn was divided and a small canal was seen within it. The severed attachment to the main uterus was closed with several interrupted medium silk sutures. The left ovary was not removed.

The specimen (Fig. 2) was later opened through the small proximal canal and a normally implanted six weeks' pregnancy complete with membranes and scant amniotic fluid was found.

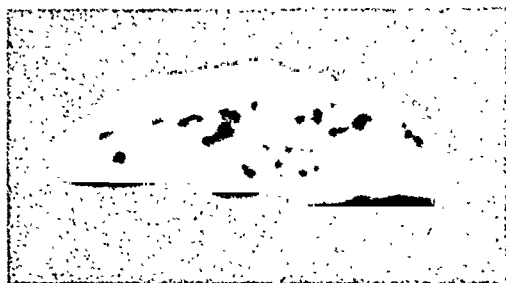


FIG. 3. Decidual cast passed from the normal uterus on the fourth postoperative day (actual size).

The postoperative course was uneventful, excepting that on the third postoperative day slight, continuous vaginal bleeding occurred. The next day a soft piece of tissue was passed per vaginam, which had the appearance and consistency of a decidual cast. (Fig. 3.) The vaginal bleeding ceased on the sixth postoperative day. The patient was discharged, asymptomatic, and with the abdominal wound well healed five days later.

#### COMMENT

In this case, a rudimentary uterine horn containing a six weeks pregnancy was removed intact, eliminating the danger of rupture with sudden death from intraperitoneal hemorrhage. In the case reported by Mulsow, rupture occurred in the fifth month of pregnancy causing the patient's death within fifteen minutes. If allowed to continue, a pregnancy in a rudimentary horn will cause rupture of the abnormal uterus in 90 per cent of cases. As pointed out by Miller, the cervical portion of such a malformed uterus is largely fibrous and therefore incapable of adjustment to increased internal pressure. If rupture does not occur, expulsion difficulties result in death of the fetus and the fetus may become mummified. In one instance, an operation for a mass, present twenty years, revealed the bones of twins in a rudimentary uterine horn. Considering the serious prognosis of these cases, it is fortunate that most incorrect diagnoses made (usually tubal pregnancy) necessitate immediate surgical interference. For this reason, comparatively few cases have been permitted to go on to rupture and death from internal hemorrhage. Since the ab-

normal uterus can not fulfill a reproductive function, the diagnosis of ectopic pregnancy is practically speaking, a correct one.

According to Williams, the majority of cases show a rudimentary horn whose proximal end does not communicate with the normal uterine cavity so that pregnancy only follows external migration of the spermatazoa or of the fertilized ovum. In our case the presence of a small canal in the fibrous proximal end of the rudimentary horn and the corpus luteum found in the ovary on the side of the deformity, eliminates the necessity for this supposition.

#### SUMMARY AND CONCLUSIONS

A comparison of the frequency of uterus didelphys and rudimentary uterine horn is made and the possibilities of making a correct diagnosis in each instance is discussed. The available literature on each condition is briefly outlined and it is suggested that more cases of rudimentary uterine horn are not discovered since they must often escape pregnancy and therefore remain uncomplicated and symptomless. A case is reported of a pregnant uterine horn found and removed during an operation performed for "tubal pregnancy." The serious prognosis of an uninterrupted pregnancy of this type is emphasized. It is felt that all such cases should be reported so that the physician may become increasingly alert to the possibility of its existence, in all atypical cases of extrauterine pelvic masses associated with amenorrhea.

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# TUMORS OF THE SMALL INTESTINE

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SINCE tumors of the small bowel usually manifest themselves early only by anemia as the result of chronic loss of blood without other definite signs or symptoms, and since visualization of these tumors is often impossible by roentgenologic examination of the small intestine until the lesion has progressed quite far, it seems worth while to stress again the importance of thorough examination of a patient who has anemia and exhibits the features of chronic loss of blood. We are presenting two cases in which the initial symptom was anemia. In one case a benign lesion of the small bowel was found at exploratory laparotomy and in the other a carcinoma of the small intestine was found.

Since practically every type of tissue except bone and cartilage is found in the wall of the small intestine, the relative rarity of tumors in this site is striking. In the literature,<sup>3</sup> the percentage of malignant lesions in the small intestine is 1 to 3 per cent of all of those in the gastrointestinal tract and benign lesions are even less frequent. At the Mayo Clinic, from 1907 to 1939 inclusive, only 108 cases of malignant tumor and forty-one cases of benign tumor of the small intestine were reported. This relative immunity of the structures of the small intestine to formation of tumors remains unexplained. The benign tumors of the small intestine are important not only because of the ease with which these lesions can be treated surgically but because of the extreme difficulty of differentiation from the malignant ones.

The types of benign tumors that have been found in the small intestine are adenoma, myoma, lipoma, neuroma, fibroma, hemangioma and various combinations of these. Approximately 50 per cent of these tumors are in the duodenum

and the remainder are almost equally divided between the jejunum and ileum.

## INCIDENCE

Although adenocarcinoma is by far the most frequent type of malignant tumor in the small intestine, it is of relatively uncommon occurrence. In a series of 4,684 cases of malignant disease of the alimentary tract, Craig reported only thirty-six primary carcinomas in the small intestine. Mayo's 108 cases of malignant lesions encountered from 1907 to 1939 inclusive represented only 1.5 per cent of the surgical lesions of the stomach and only 1.4 per cent of those in the colon for the same period. Jefferson found only 130 (3.1 per cent) primary carcinomas of the small intestine in 4,177 malignant lesions of the intestinal tract and Aaron found seventeen in 343 cases.

Various types of sarcoma of the small intestine have been reported, but sarcoma occurs only approximately half as frequently as carcinoma. The most common type of sarcoma in the small intestine is lymphosarcoma, which is found in the ileum in 60 per cent of these cases and occurs most frequently in children and young adults.

Carcinoids, which are more common in the appendix than in other sites, occasionally do occur in the small intestine, but there is some question as to whether these tumors should be considered as truly malignant lesions. Krompecher, Bunting and Oberndorfer have compared carcinoids to basal cell carcinomas of the skin because of the similarity of these two lesions. These tumors may be single or they may be multiple as they were in 30 per cent of Humphreys' series of 152 cases. Carcinoids usually spread by local invasion, but cases have been reported in which extensive

evidence of metastasis has been found in regional lymph nodes and liver. Cooke has collected a series of 104 cases of carcinoid of the intestines. In twenty-one the carcinoid was malignant and in eight it had metastasized. In Ariel's series, 8.3 per cent of all neoplasms in the small intestine were carcinoids.

#### DIAGNOSIS

The symptoms of tumors of the small intestine are usually vague, and often intermittent before the onset of complete obstruction. These symptoms which are relieved completely between attacks are cramp-like abdominal pain, nausea and vomiting. The onset of severe hemorrhage, perforation or acute obstruction, however, may be sudden. Loss of weight is inconstant early in the disease, as is constipation. The malignant growths are most likely to occur in the fourth and fifth decades of life, but may occur at any age. Results of physical examination are usually negative unless intussusception is present and then the typical tumor mass may be palpable. Shallow, Eger and Carty were able to palpate the tumor in 75 per cent of thirty-eight cases. Routine roentgenologic studies usually give negative results unless the tumor has caused obstruction owing to its intraluminal mass or because of intussusception.

Another symptom is anemia with resultant weakness and fatigability. The repeated finding of occult blood in the stools and progressive anemia are the only laboratory findings that aid in diagnosis. It is believed that the anemia is best explained on a basis of direct loss of blood from the lesion as these tumors are very apt to ulcerate and bleed. Good and MacCarty found that loss of blood was present in twenty-eight of thirty-five cases of tumors of the small intestine.

In many instances, anemia may be the only symptom and often the patient is treated for anemia and no search is made for its cause. The anemia associated with chronic loss of blood is characteristic in

that the concentration of hemoglobin as well as the number of erythrocytes is reduced. The number of leukocytes is usually unaffected, but may be slightly increased above normal. The number of reticulated erythrocytes is normally increased and microscopic examination of the blood smears reveals anemia with features of increased regeneration of erythrocytes. Anisocytosis with regenerative macrocytes, many of which may be polychromatophilic, will be present. The blood platelets are usually normal or slightly increased in number and the leukocytes are rarely immature although there may be a slight shift to the left of the neutrophils.

In acute loss of blood, there is usually severe anemia and the hemoglobin and erythrocytes are reduced in about equal proportion. Following acute hemorrhage, the regenerative changes in the erythrocytes are more definite than those seen when chronic hemorrhage is present and an occasional normoblast may be found. Slight immaturity of the granular leukocytes is present and in extremely severe hemorrhage a leukemoid reaction may occur which might lead to the erroneous conclusion that the patient has leukemia. However, when the number of blood platelets is normal or slightly increased, the history of hemorrhage should suggest a leukemoid reaction rather than leukemia. When occult blood is found repeatedly in the stools, primary hemorrhagic disease or aplastic anemia, leukemia, hypoprothrombinemia or secondary purpura must be considered as possible diagnoses. A carefully taken history and an estimation of the various coagulating factors of the blood, as well as examination of the blood smears, should help distinguish these conditions from hemorrhage due to a tumor in the small intestine.

Because tumor of the small intestine occurs relatively infrequently, the symptoms are vague and physical findings are often negative, diagnosis is not only difficult, but many times impossible to

make. When the diagnosis is correctly made clinically, it is usually made by the process of exclusion. When a history of intermittent crampy abdominal pain accompanied by nausea and vomiting is given, when occult blood is found in the stools on several examinations and when roentgenologic examination of the stomach, duodenum and colon gives negative results, the possibility of a tumor in the small bowel should be considered. Although a high percentage of tumors in the small bowel bleed and hence cause tarry stools, there are numerous other causes of tarry stools. At the Mayo Clinic between January 1, 1939, and January 1, 1942, only thirty-five tumors of the small intestine were seen, but in this same period, 1,133 patients who had gastric carcinoma and 8,188 patients who had peptic ulcer were examined. Only when the diagnosis of other lesions in the upper and lower parts of the gastrointestinal tract has been definitely excluded should special roentgenologic studies of the small intestine be advised. Now that special technics are being used and experienced roentgenologists are making the roentgenologic examination, the site and type of tumor is being determined preoperatively with increasing frequency.<sup>12</sup>

#### TREATMENT

The only treatment for these tumors is surgical removal of the tumor and restoration of the continuity of the intestine by end-to-end or side-to-side anastomosis. Before surgical procedures are attempted, the anemia and hypoproteinemia should be treated by means of transfusions of whole blood and plasma, the bowel should be decompressed by use of the Wangensteen suction and the electrolytes should be restored to normal. Complete recovery is to be expected if the tumor is benign, but the prognosis for those patients who have malignant tumors is poor, as these tumors metastasize early. Because of the vague, insidious onset of symptoms, several months usually elapse before these patients seek aid. By this time, operation is only

palliative. Craig found glandular involvement in 53 per cent of his thirty-six cases, and Shallow reported that in thirty-one of his thirty-eight cases extension or metastasis had occurred. Roentgen therapy is of little value.

#### CASE REPORTS

**CASE 1.** A white student, twenty-one years old, was admitted to the hospital February 4, 1945. He complained of weakness of two months' duration. He had never noticed tarry stools nor had he had any gastrointestinal symptoms except occasional, mild periumbilical cramps. Although he had not lost weight, he had failed to gain weight for the previous two months as he had when he first entered on the V-12 program.

Physical examination on admission gave essentially negative results except for signs of severe anemia. Erythrocytes numbered 2,440,000 per c. mm. of blood and the level of hemoglobin was 38 per cent of normal. No ova or parasites were found on repeated examinations of the stools, but always the stools contained occult blood, grade 4, on a grading basis of 1 to 4 in which 1 represents the least and 4 the most blood. Repeated examinations of the gastrointestinal tract, which included studies in which the barium enema was used, and roentgenologic studies of the thorax gave negative results. Results of other laboratory examinations including leukocyte count and differential count, icteric index, Kahn test for syphilis and platelet counts, were within normal limits. Examination of the blood smears revealed polychromatophilia of the erythrocytes, an occasional normoblast and a slight left shift to the neutrophils.

After transfusions with whole blood, the patient underwent exploratory laparotomy on February 22, 1945. A small, hard, annular tumor of the jejunum was removed (Fig. 1) and end-to-end anastomosis was made. No nodules were palpable in the liver, but numerous enlarged lymph nodes were present in the mesentery and retroperitoneal space. These nodes could not be excised. Pathologic examination of sections of the excised tumor revealed it to be adenocarcinoma, grade 2 (Broders' method). Following uneventful convalescence, the patient was transferred to another naval hospital for further observation,





FIG. 1. Annular adenocarcinoma of jejunum. Note that the intestine was patent. This explains the minimal gastrointestinal symptoms.

treatment and dismissal. At the time of this report, he is free of symptoms, but the prognosis is considered to be grave.

**CASE II.** A white sailor, twenty-eight years old, first was admitted to a naval hospital, February 20, 1945. He complained of abdominal cramps, nausea and vomiting. Physical examination gave negative results and when his symptoms subsided spontaneously, he was returned to duty February 22, 1945. He was free from symptoms until March 13, 1945, when he was again admitted to the hospital with the same complaints. Physical examination again revealed nothing abnormal and this attack also subsided. He returned to duty March 20, 1945. While at sea, he experienced mild attacks of abdominal pain and some nausea, but no severe symptoms. On April 10, 1945, while on leave, he had a severe attack and was admitted to the hospital.

Physical examination gave negative results except for signs of loss of weight (30 pounds [13.6 kg.] in three months). Repeated examination of the gastrointestinal tract with special studies of the small intestine gave negative results. Erythrocytes numbered 4,000,000 per c. mm. of blood and the value for hemoglobin was 78 per cent of normal. Examinations of the stools on several occasions revealed occult blood grade 4+. All other laboratory findings were within normal limits. While in the hospital, the patient had several severe attacks of abdominal pain, nausea and vomiting and he continued to lose weight.

On July 4, 1945, exploratory laparotomy was performed. Forty inches (101.6 cm.) from the ileocecal valve the wall of the bowel was intussuscepted for approximately 4 inches (10.2 cm.). This was partially reduced, but because edema of the intestinal wall was severe, it was deemed advisable to remove the 8 inches (20.3 cm.) of



FIG. 2. Leiomyoma of ileum. Sections have been cut for microscopic examination. Note intussusception of the wall of the intestine.

intestine which contained a tumor and was the site of the intussusception (Fig. 2), and to make an end-to-end anastomosis. There were no palpable nodes in the mesentery or liver. The pathologic examination of sections from the excised tumor revealed it to be a leiomyoma with no evidence of malignancy. The patient's convalescence was uneventful and he returned to full duty.

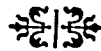
#### COMMENT

These cases are presented to emphasize the importance of exploratory laparotomy in patients who have secondary anemia due to loss of blood from the gastrointestinal tract. In Case II, the anemia was slight; but, nevertheless, examination of the smears revealed the increased regeneration of erythrocytes and the typical picture of anemia due to loss of blood. A bleeding lesion of the small intestine should be suspected when this type of anemia is associated with occult blood in the stools. It should be suspected more strongly when the occult blood is found while the patient is on a meat free diet even though no lesion of the gastrointestinal tract can be demonstrated on roentgenologic examination. Under these circumstances exploratory laparotomy should be considered.

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*Intestinal obstruction* may occur from herniation of bowel through the opening in the transverse mesocolon into the lesser peritoneal cavity. Nearly all of the small intestines may enter the lesser peritoneal cavity, protrude through the gastrocolic omentum, and hang in front of the transverse colon. This, as well as secondary adhesions, should be relieved by reoperation.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

# PRIMARY LIVER TUMORS

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THE liver possesses truly remarkable regenerative properties. Following any injury to hepatic tissue there is an attempt at regeneration. The forces that normally limit regeneration following injury are not well developed in the liver, because in many cases the regenerative process is excessive resulting in the formation of an adenoma and later even a carcinoma. There is a uniform gradation between nodular hyperplasia, multiple adenoma and multiple carcinoma. These three stages may even be seen at one time in one liver.<sup>5</sup>

It is largely because of this peculiar pathological process that there is such confusion in the literature about the nomenclature and potential malignancy of primary liver tumors. Many of the different names under which primary hepatic neoplasms are discussed are merely different phases or stages of one continuous pathological process. This basic process from injury, regeneration, hyperplasia, benign tumor to malignant tumor may proceed rapidly, slowly, or practically stop altogether at any of these stages. Any of the various forms of hyperplasia may occur with or without cirrhosis.

Primary hepatic neoplasms are of four general classes, liver cell tumors (known as hepatomas), bile duct cell tumors (known as cholangiomas), mixtures of these two types, and tumors of the supporting structures (blood vessels, fibrous tissue, etc.). Any of these types may be benign (adenoma) or malignant (carcinoma or sarcoma).

After an injury the liver cells are much more active than the bile duct epithelium in proliferating. This is probably the reason most primary liver tumors arise from liver cells rather than from the bile duct epithe-

lium.<sup>4</sup> Wilbur, Wood and Willet report that 92 per cent of their series of cases of primary carcinoma of the liver had tumors of the liver cell (hepatoma) type.<sup>16</sup>

In general, a malignant liver tumor that is composed of highly differentiated cells spreads within the liver and to the local lymph nodes. A tumor of anaplastic cells is much more likely to metastasize to distant sites—bone, lungs, etc. Hepatomas invade the capillaries very early, even when devoid of other evidences of malignancy, and tend to metastasize within the liver at first.<sup>5</sup> There is very general agreement in the literature on the high degree of potential malignancy of all primary liver tumors, especially the tumors composed of liver cells variously designated as adenomas, hepatomas and benign hepatomas.<sup>1,4,5,11,13,15</sup> In addition to malignant transformation, adenomas may undergo necrosis from bile secretion, hemorrhage, or twisting of their pedicles.<sup>7,11</sup> Spontaneous erosion of a primary liver tumor with intra-abdominal hemorrhage has been reported by several authors.<sup>12,13,16</sup>

A large amount of experimental investigation into the possible etiological factors of primary liver tumor has been done. Among the commonly considered predisposing and causative factors may be mentioned stasis,<sup>5</sup> cirrhosis, congenital malformations (usually hepatic or adrenal rests), avitaminosis<sup>4,8</sup> (especially when combined with a very high fat diet),<sup>15</sup> age, sex, race, hormonal changes, syphilis, parasites of the gastrointestinal and biliary passages, and certain ingested chemicals. In twelve hundred carefully studied cases of primary liver tumors of all types, Warvi found cirrhosis present in 46 per cent.<sup>15</sup> Ewing feels that cirrhosis occurs in 85 per cent of primary liver tumors of



FIG. 1. Gross specimen, benign hepatoma; pedicle of tumor, lower right.



FIG. 2. Gross specimen, benign hepatoma, cut section; illustrating irregular, coarse lobulations (the oblique shadow is a cut made by the pathologist's knife).

hepatic cell type (hepatoma) and in 50 per cent of primary liver tumors of the bile duct cell type (cholangioma).<sup>5</sup> Other students of the subject feel that 61.3 per cent of primary liver carcinomas arise in cirrhotic livers.<sup>4</sup> Most investigators feel that single, encapsulated, relatively benign liver cell tumors occurring in youth or adolescence probably represent a type of adenoma due to a congenital malformation<sup>5,10,15</sup> The case herein reported may be such a tumor. The highest incidence of primary liver tumors occurs in the fifth and sixth decades of life, but they may occur at any age. Approximately 90 per cent of primary liver carcinomas occur in males.<sup>1,16</sup> Primary liver tumors, usually of the malignant type, are much more common in China, India and South Africa than in other parts of the world. Previously environment factors, especially schistosomiasis in these areas, were thought to be responsible. Recent studies would indicate the incidence of primary liver tumors are related to racial and not environmental factors and that schistosomiasis does not play a role in liver cell carcinoma, at least in the Chinese.<sup>6,12</sup> Cunningham found a definite history of alcoholism in seven of his fourteen reported cases of primary liver

carcinoma and referred to a series of 62 cases reported by Gustafson with 35 per cent giving a definite history of alcoholism.<sup>4</sup> It has not been determined if this is a direct toxic effect stimulating carcinomatous changes or whether the concomitant avitaminosis leads to cirrhosis which in turn predisposes to primary carcinoma of the liver. A chemical known as "butter-yellow" will induce a high incidence of cirrhosis with eventual carcinoma in rats. This effect is largely prevented by high protein diets and vitamin B.<sup>4</sup> Selenium fed to rats induces a subacute liver damage which after three months produces a chronic nodular cirrhosis. Both hepatic cell adenoma and carcinoma were found in these experimental rats eighteen months after beginning the seleniferous diets.<sup>9</sup> That hormonal changes play a significant role either directly or indirectly through metabolic changes is suggested by Burns and Schenken. Spontaneous primary hepatomas in male mice occurred in 27 per cent of breeding male mice and in 6 per cent of non-breeding male mice. In breeding female mice the incidence of this tumor was zero, but in non-breeding females the incidence was 10 per cent.<sup>2</sup>

If the groups of mice used in some categories were larger, greater significance could be given to these observations. The last etiological factor to be considered is chronic infection. Cunningham found lues in four of fourteen patients with primary liver cancer, and in this same article quotes Gustafson who found lues in 22 per cent of his 62 patients studied.<sup>4</sup> Care must be taken to eliminate "false positives" from such studies where the serological tests are altered merely by the tumor present.

The symptoms produced by primary hepatic neoplasms vary with the type, size, location and degree of malignant transformation present. One carefully studied series of cases of primary hepatic carcinoma discloses the following incidence of findings or symptoms:

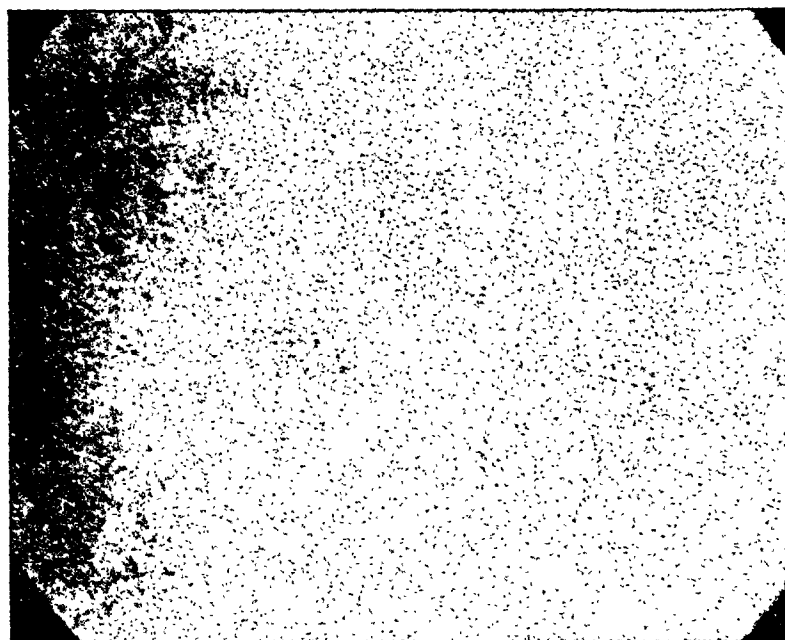
abdominal mass. ....	77% (often with tender areas)
abdominal pain. ....	72%
indigestion. ....	uncommon
jaundice. ....	60%
ascites. ....	60% (often bloody or blood tinged)
weight loss. ....	52.5%
leg edema. ....	42.5%

Other symptoms or physical findings seen in liver carcinoma are: Alterations of temperature with fever (Warvi found this in 50 per cent)<sup>14</sup> or hypothermia, weakness, splenomegaly, prominent superficial abdominal veins, pain in the back or shoulders, or urinary symptoms if the tumor presses on the right kidney. Anemia is often seen together with reduction in liver function as demonstrated by at least some of a series of liver function studies. Adenomas usually produce only a minimum of symptoms; dyspepsia, a mass, and a sensation of weight or fullness in the right upper abdominal quadrant are the more common findings and symptoms. Portal or biliary obstruction, partial ureteral obstruction, torsion of the tumor pedicle, and erosion of a blood vessel in the tumor may occasionally occur. Fever, early pain, weight loss, anemia and weakness, the symptoms seen in patients with a carcinoma, are very rare

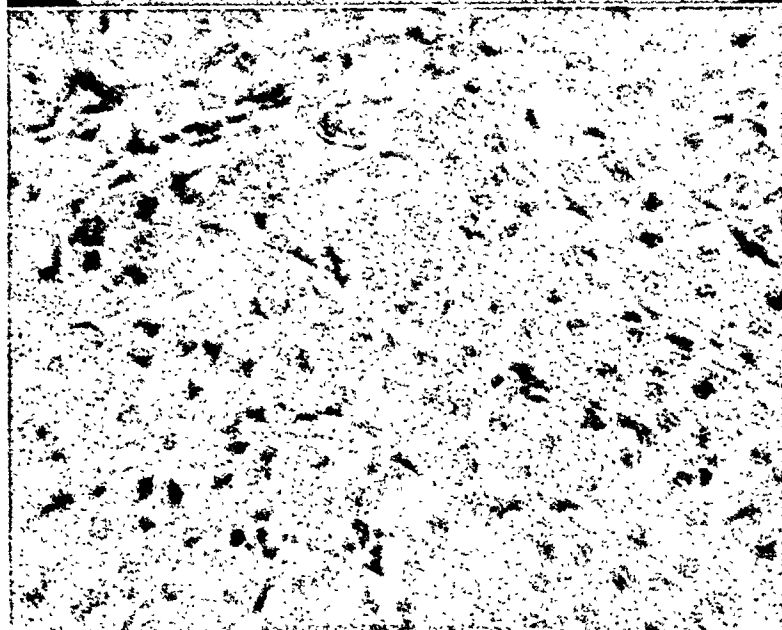
or absent in patients with adenoma. Usually in a patient with an adenoma the liver function tests are normal. Special diagnostic aids for liver tumors beyond those previously mentioned include: determination of the serum alkaline phosphatase, peritoneoscopy, injection of thorium dioxide, pneumoperitoneum studies and aspiration liver biopsy over a palpable nodule. None of these special tests were performed on the case herein reported, either because they were not obtainable or they were considered inadvisable in this particular case. A serum alkaline phosphatase above 10 Bodansky units, in the absence of any other cause of congestion in the liver or generalized bone disease, as Paget's disease, metastatic bone disease, etc., probably indicates liver malignancy.

The prognosis for patients with hepatic tumors depends on the benignity or the malignancy of the tumor mass, the type of cells (patients with bile duct cell tumors have a poorer prognosis than patients with liver cell tumors), and on the time and the completeness of the surgical removal. After the appearance of a malignant tumor life is seldom prolonged over four months.<sup>5</sup>

The treatment of primary hepatic neoplasms is early thorough surgical excision in all cases where the tumor is so situated that this can be accomplished. Early radical surgery is justified in these cases because untreated, the prognosis is very poor. Neither a primary liver adenoma nor a carcinoma is amenable to radiation therapy.<sup>15</sup> The first reported successful resection of the liver for a solitary adenoma was by W. W. Keen, in 1892. Several more cases were reported by this same surgeon in 1899.<sup>7</sup> Since that time many technical improvements make such surgery much safer. Control of hepatic bleeding can now be accomplished by electrocautery and hemostatic sutures. Radical excision of the tumor and a margin of normal liver tissue, as soon as the diagnosis is made or strongly suspected, would eliminate many of today's failures in dealing with this problem.<sup>3</sup>



3



4

FIG. 3. Photomicrograph (low power) showing lack of liver lobule arrangement and rapidly proliferating bile ducts.

FIG. 4. Photomicrograph (high power) showing masses of liver cells without typical cord arrangement. At the upper left is a proliferating bile duct.

At present, all too frequently, recurrences appear several months or years post-operatively due to too late or too conservative surgery. Warvi has recently written an excellent review of this subject. In a series of thirty-three patients having resections of hepatic adenomas there was 9 per cent operative mortality and recurrence in 21 per cent. In another series 40 per cent of the patients are living and well three to seven years following liver resection for

primary carcinoma.<sup>15</sup> Prior to June, 1945, 223 well authenticated cases of resection of primary liver tumors had been reported.<sup>14</sup>

#### CASE REPORT

This is the report of the operative removal of an apparently benign hepatoma from a twenty-three year old sailor.

This twenty-three year old sailor entered a Naval hospital overseas in November, 1945, complaining of intermittent nausea. Because of

this symptom and the presence of an abdominal mass, he was evacuated to the United States. He was admitted to the U. S. Naval Hospital, Farragut, Idaho, on December 21, 1945. The history disclosed complete absence of symptoms except for intermittent nausea and vomiting for one year. There had been no loss in weight. No significant information was gleaned from his past medical history or family history. There was no history of trauma, alcoholism, syphilis, parasitic infestation, ingestions of poisons or liver disease of any kind.

Physical examination was normal except for the presence of an abdominal mass. This mass was located in an almost entirely filled right upper abdominal quadrant, extending one inch to the left of the mid-line and one inch below the umbilicus. It was readily palpated, freely movable, smooth, non-tender, firm, non-pulsatile and it moved slightly with respiration. There was no emaciation, jaundice, weakness, petechia, spider angiomas, fever, enlarge lymph nodes, pectoral alopecia, splenomegaly or engorged abdominal veins. Two cholecystograms showed a non-functioning gallbladder; the erythrocyte sedimentation rate (Wintrob) was 4 mm. in one hour; the serum proteins were normal; the bromsulfalein liver function test, prothrombin time, bleeding and clotting time, chest x-ray, serum bilirubin, tuberculin reaction, blood Kahn, urinalysis, blood counts, blood platelet count, blood malaria smears, cephalin-flocculation liver function test and blood cholesterol were all normal. X-ray studies of the gastrointestinal tract demonstrated only displacement of the colon and small intestines downward and to the left. Both intravenous and retrograde pyelograms demonstrated early right hydronephrosis.

On January 25, 1946, an abdominal laparotomy was performed. Through a right transrectus incision a nodular firm tumor measuring 20 by 10 by 6 cm. was brought into view. The mass was attached to the margin of the right liver lobe by a very vascular pedicle; the gallbladder was adherent to the medial anterior surface of the tumor. This was dissected free, the vessels in the pedicle were separately ligated and the mass divided at the liver margin. The blood supply to the tumor mass was carried by three large vessels, each approximately 1 cm. in size. These vessels emerged from the undersurface of the right liver lobe and continued on the posterior medial surface

of the liver tumor. Bleeding was controlled by interrupted mattress chromic catgut sutures through the liver margin. Approximately 400 cc. of blood were lost during the operative procedure. There was no evidence of tumor formation elsewhere in the liver or abdomen. The biliary tree was examined and found to be normal. The postoperative course was uneventful. The following is the pathologist's report of this specimen.

*"Gross Description:* Specimen consists of a tissue mass approximately 13 cm. in diameter, showing irregular, coarse lobulations. The external surface is smooth and glistening, except for one small area about 1 cm. in diameter, apparently the pedunculated base of the mass. Consistency is uniformly firm. The cut surface reveals generalized lobular structures composed of reddish-brown, firm tissue, organized in lobules varying from 1 to 3 cm. in diameter with a network of dense white supporting tissue separating the lobules.

*"Microscopic Examination:* Large groups of liver cells are arranged in irregular cords and masses and roughly divided into lobules by fibrous bands of varying size. There is no true 'lobular' arrangement, and no portal triads are noted in the septae. There are numerous small actively proliferating bile duct buds which wander through the septae with no obvious destination. No abnormal mitoses are seen and there is no evidence of any malignant change. No inflammatory cells are present.

*"Microscopic Diagnosis:* Pedunculated hepatoma."

There has been no postoperative nausea or vomiting. Of special interest is that four weeks postoperatively x-ray studies demonstrated a normally functioning gallbladder, and no evidence of hydronephrosis or other upper urinary tract pathology. Most of the same laboratory tests were repeated postoperatively plus an hippuric acid liver function test, and all were within normal limits. The patient is now asymptomatic and follow-up studies will be carefully done in this case for evidence of recurrence or other complications.\*

#### SUMMARY

1. The literature on primary hepatic neoplasms is reviewed.

\* In a recent communication from the patient, dated January, 1947, he states that he is entirely symptom-free without evidence of intra-abdominal mass formation nor evidence of malignancy.

2. The excision of an apparently benign hepatoma, probably of congenital origin, is reported.

3. The overwhelming preponderance of investigators believe that all primary hepatic neoplasms are potentially if not actually malignant.

4. Widespread early surgical excision is the only effective treatment for primary hepatic neoplasms.

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# SPIGELIAN HERNIA

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**S**PIGELIAN hernia, or spontaneous lateral ventral hernia, is one occurring through the semilunar or Spigel's line.

To review the anatomy, we note that the semilunar line corresponds to the lateral border of the aponeurosis of the transverse abdominis muscle, and runs from the costal margin to the pubes, lateral to the edge of the rectus. The internal oblique and external oblique fuse loosely with the semilunar line but may be separated by blunt dissection.

Practically all Spigelian hernias occur at the level of the semicircular line which is located several inches below the umbilicus approximately halfway from umbilicus to pubes, and is the curved line below which the posterior rectus sheath is absent. In fact, the semicircular line usually forms part of the ring of the Spigelian hernia.

The hernial opening is a hiatus in the linea semilunaris. Various theories have been advanced for this defect, but no one knows the exact cause of its occurrence.

The sac, composed of peritoneum and transversalis fascia, pushed through this hiatus in the semilunar line, becomes surrounded by fibers of the internal oblique and ends beneath the aponeurosis of the external oblique. Thus the hernia is interparietal or "masked." In addition, there is usually a well marked properitoneal lipoma.

In summary, the Spigelian hernia is one occurring at the outer border of the rectus muscle, usually at the level of the linea semicircularis and is interparietal.

These hernias vary in size from a walnut to an orange. The ring measures from 0.5 to 2.0 cm. in width. They strangulate readily, and the only treatment is surgical repair. This consists of high ligation and excision of the sac with approximation of

the transversalis fascia and transverus and internal oblique muscles.

## CASE REPORT

A forty-six-year old Mexican male was admitted to the hospital April 20, 1945. His complaints were cramping lower abdominal pain and vomiting of one day's duration. The pain was accompanied by gurgling in the abdomen. There was no diarrhea. History was difficult to obtain. He was sent to the hospital with a diagnosis of acute appendicitis.

On examination it was noted that he grimaced with pain at intervals of a few minutes' duration concurrently with gurgling of gas in the right lower quadrant. Palpation revealed a definite gurgling under the skin in the right lower quadrant, as though there was a muscle weakness allowing a direct hernia. The leucocyte count was 10,700, with 70 per cent polymorphonuclears. He did not appear to be acutely ill; the condition was tentatively diagnosed as gastro-enteritis and the patient was given sedatives.

The right lower quadrant findings were described and recorded, but those in charge were puzzled by the odd location for a hernia.

The following morning the patient said he slept well, ate a good breakfast and had no more cramps. Gurgling continued to be felt in the right lower quadrant.

The next day a soft mass was definitely palpable in that region; the mass became hard, tense and distended within twenty-four hours. The patient also had a return of cramps and vomiting. He was taken to surgery at once with a diagnosis of strangulated ventral hernia.

The abdomen was opened with a transverse incision over the rounded mass. The external oblique aponeurosis covered it and was divided in line with its fibers. A large, tense sac was then encountered, just lateral to the rectus muscle and on a line between the anterior superior iliac spine and the umbilicus. Upon opening the sac, bloody fluid spurted out. A loop of dark but viable ileum was present in the sac. The neck was narrow and very fibrous.

Reduction was accomplished by dividing the neck of the sac medially. The ileum was partially retroperitoneal and constituted a sliding hernia. It was treated by dividing the peritoneum along each side of the ileum and suturing the two edges behind it. This allowed all contents to be replaced.

The sac was then closed transversely with interrupted No. 1 chromic sutures, the excess sac being excised.

The transversus and internal oblique muscles were approximated with interrupted chromic sutures. The external oblique was closed with a running suture. Subcutaneous tissue was approximated and the skin closed with clips.

The postoperative course was uneventful. He was discharged on the twelfth day. The patient returned to the clinic one month later apparently entirely healed.

A survey of his past history revealed that the patient had had two previous admissions for what appeared to be the same complaint. He was admitted October 15, 1943, with the complaint of abdominal pain and vomiting of five days' duration. He had had some burning on urination. The urine was described as "smoky" in the admitting room, and contained crenated red cells, so he was admitted to urology. Cystoscopy and retrograde pyelography revealed no lesion. His urine was clear

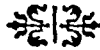
and it was assumed that he had passed a stone. At any rate he recovered spontaneously from his pain and was discharged on the fifth day.

He was also admitted May 16, 1943, with the complaint of cramping abdominal pain and vomiting. Pains were intermittent. Examination revealed the abdomen to be not particularly tender; white blood cells 10,200; 73 per cent polymorphonuclear cells. It was thought that he had a subsiding appendicitis and he was not operated upon. He was discharged on the fourth day.

It would appear that his difficulty on these two previous admissions was obstruction in a Spigelian hernia. The fact that it went on to strangulation during his third visit brought him to surgery and the pathological condition was disclosed. Had one been aware of Spigelian hernia the diagnosis might have been made by palpation of gurgling beneath the skin.

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# INTESTINAL LIPOMA SIMULATING CARCINOMA OF THE SIGMOID COLON

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**T**HIS case of intestinal lipoma demonstrated clearly the necessity for always being alert to the possibility that a lesion, supposedly malignant, may in reality be a benign one of a rare type, not requiring the radical measures employed in the surgical treatment of a malignant lesion. The diagnosis of lipoma was not made, nor even suspected, until after sectioning of the tumor for pathologic study, but fortunately, the lesion was so situated in the bowel that a permanent colostomy was not necessary.

The dearth of literature on intestinal lipomas, particularly the subserous form, testifies to the fact that these tumors are rare. Mayo Clinic records revealed that out of 44,654 intraperitoneal operations only six intestinal lipomas were encountered.<sup>2</sup> Schottenfeld<sup>4</sup> recently collected all the available material on lipomas of the gastrointestinal tract and was able to find reports of only 275 cases. The small intestine appeared to be the predominant site since in 154 of these cases, the lipomas occurred in this portion of the tract. The tumors in the remainder of cases occurred in the stomach or colon. In only fifteen cases were the tumors of the subserous type.

## CASE REPORT

The patient, a fifty-five year old woman, was admitted to Garfield Hospital complaining of low abdominal pain of two days duration and prolapse of the uterus of six months duration. While her appetite was good, she had not overeaten, and she attributed the abdominal pain to gas. She stated that it had become impossible, during the past six months, for her to pass gas freely through the rectum. Constipation was chronic and enemas were taken with great difficulty because of her

inability to expel them properly. Occasionally blood streaked stools were passed. About six months ago, when she first noticed the prolapse of the uterus, she went to a local physician who inserted a vaginal pessary. She was not relieved by this measure and continued to complain of discomfort particularly when seated.

Her past history disclosed no surgery or serious illnesses. However, healed pulmonary tuberculosis was found, but investigation of a series of x-rays, taken by the Navy Department, showed it unchanging. She had no dysuria or incontinence. Menarch—16 by 21 by 3. She had two children by normal delivery. Fifteen years ago she was told that she had a fibroid tumor of the uterus, but menopause, without complications, occurred when she was forty-five years of age and no bleeding or discharge has been noted since that time.

Physical examination revealed the following pertinent abnormalities: some tenderness over Lanz Point but no rigidity, a third degree rectocele, a small uterus and a free mass, the size of a base ball, in the cul-de-sac. A preoperative diagnosis of rectocele and pelvic tumor, type undetermined, was made.

Under spinal anesthesia, the rectocele was corrected by a posterior colporrhaphy. The patient was then placed in the Trendelenburg position and a midline, subumbilical incision was made in order to explore the abdomen. The reproductive organs were atrophic but normal. A tumor, approximately 8 cm. in diameter, was found in the mesentery of the sigmoid colon, about 20 inches above the anus. It appeared indurated and firm, but not gristly, and a small area of necrosis was found on one side. Although there were no lymph node enlargements felt, there were several small nodules on the anterior peritoneal wall. One of these was excised for microscopic study. The liver was normal to palpation. Since the tumor involved the intestinal lumen, an obstructive resection of about 10 cm. of bowel was done, using the

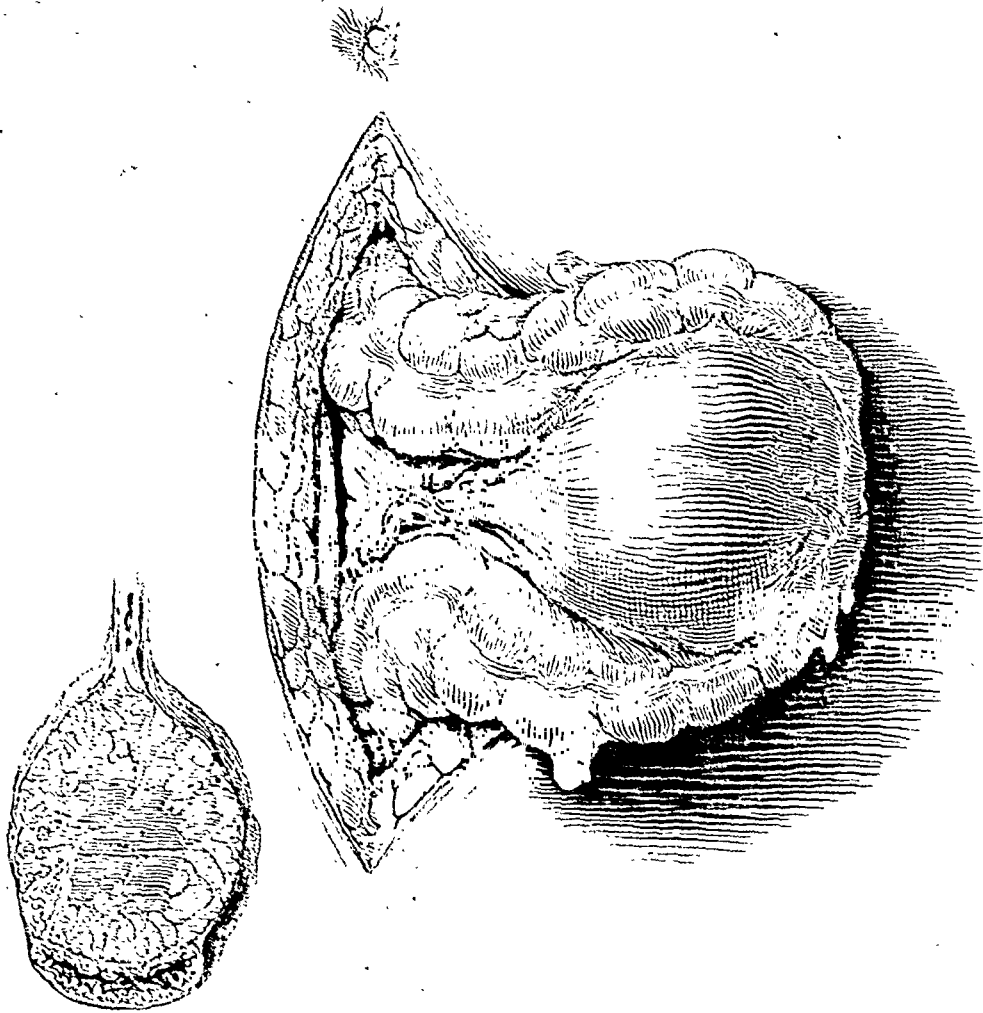


FIG. 1. Drawing of lipoma found in the case presented; gross section of the tumor at left.

Rankin clamp. The sigmoid mesentery was then mobilized in order to prevent tension on the exteriorized segment, and the wound was closed around the bowel by the Mikulicz method. After the skin was approximated, the tumor was excised above the clamp.

A spur crusher was applied on the third post-operative day and following its removal, feces passed through the rectum as well as through the colostomy. An extraperitoneal closure of the colostomy was necessary on the thirty-seventh postoperative day since it showed no tendency to close spontaneously. The postoperative condition of the patient was good, the recovery was uneventful and a cured result was obtained.

Terry and paraffin sections from the "lymph node" and the tumor showed them both to be composed entirely of fatty tissue and fibrous trabeculas. The nodule, which resembled a lymph node on gross examination,

was considered to be a nodule of mesenteric fat, indicating that there had been an involvement of the mesentery. The tumor was covered by a layer of cuboidal cells (peritoneum) and several spaces, which evidently represented infoldings of this membrane, were lined with similar cells. The pathological diagnosis was subserous lipoma.

#### COMMENTS

Moore<sup>3</sup> stated that the subserous form of lipoma arises from the appendices epiploica and is found more frequently in the small intestine than in the transverse, descending or sigmoid colon. Geschicter,<sup>1</sup> in a discussion of lipid tumors as a group, mentioned that a lipoma may involve the mesentery. The exact origin of the tumor discussed in this report was obscure, as the drawing demonstrates. However, since

the appendices epiploica would not arise between the leaves of the mesentery, the tumor was probably a primary lesion of the mesentery rather than of the sigmoid colon *per se*.

While the clinical picture and gross examination of the tumor at operation, with its firm and indurated appearance, indicated a scirrhus type of tumor of low grade malignancy, there were features which suggested a benign lesion of the intestine. First, despite the fact that the patient was told fifteen years ago of a fibroid tumor of the uterus, she continued to have normal menstruation and, later, uneventful menopause. Second, the complaints of long standing constipation and difficult defecation were not compatible with a carcinomatous condition. The case was not only confusing but potentially tragic because if the lesion had been 6 inches lower in the bowel, a Mikulicz type of operation would have been impossible and an abdominoperineal resection would have been done.

Even though tumors of the sigmoid colon have been found to respond best to

treatment by obstructive resection, if the pathology had been established at the time of operation, a primary anastomosis would have been feasible. Certainly this procedure would have been in order, after thorough preparation of the patient, if the lesion had occurred at or below the rectosigmoid junction.

#### SUMMARY

1. A case of subserous intestinal lipoma which grossly resembled carcinoma is presented.
2. Symptomatic lipomas of this type are believed to be of long standing.
3. Such tumors merit the closest consideration in order to avoid radical surgery in their treatment.

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# AN UNUSUAL COMPLICATION OF AN INGUINAL HERNIA\*

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WHILE the complication in the following case was unrecognized at the outset, successful ultimate recovery was obtained by the orderly pursuit of definite principles for the treatment of strangulated inguinal hernia. The major principles involved are: (1) Strangulated hernia requires immediate reduction of the hernia, (2) If the hernial sac is reduced to a single layer comprised of peritoneum alone, untoward complications may be avoided.

## CASE REPORT

This is the case of T. F., a fifty-three-year old white male patient admitted to the Methodist Hospital in December, 1941. The patient was admitted for the treatment of incarcerated right inguinal hernia of twelve hours duration. Subsequently he had vomited three times and had aching pains in the abdomen. Twenty-eight years previously he had been operated upon for bilateral inguinal hernias. Twenty-two years ago they both recurred, but have been reducible until the present illness. Examination revealed an obese white male, appearing acutely ill, whose pertinent positive findings were limited to the right inguinal region. Beneath the previous hernioplasty scar and descending into the scrotum was a tender, firm, irreducible mass about three inches in diameter. The left inguinal region revealed a recurrent incomplete hernia without incarceration.

The patient was prepared and operated upon under 1 per cent Procaine Hydrochloride, local anesthesia, with a supplement of gas, oxygen and ether, (A. J. V.) An incision five inches in length was made above the old scar and over the mass. Because of the previous operation plus the edema secondary to the incarceration, identification of the structures was difficult. However, the mass was found to be a hernial sac, measuring four inches in depth, three inches in width, and one half inch at its neck. The sac was thick walled. Its medial face was

adjacent to and adherent to a fairly thin walled structure which contained fluid and descended into the scrotum. The hernial sac was divested of all its layers down to the peritoneum and was separated from the medial structure described above. The hernial sac was then opened, revealing eight inches of grayish edematous intestine. The intestine bore no plastic exudate. Its serosa remained intact and peristalsis was present. There was no discoloration of its mesentery. The intestine was reduced into the abdomen, and the sac closed with interrupted chromic No. 1 and excised at its neck. The structure described as lying medial and below the incarcerated hernia was considered to be a hydrocele and no steps were taken to remedy it. The aponeurosis of the external oblique was reconstructed with chromic No. 1.

The patient's postoperative course was satisfactory, except for a persistent induration most noticeable at the base of the scrotum on the right side. This was felt to be due to the "hydrocele," plus the induration of the cord. On the eighteenth day postoperative the patient stated that the mass in the right inguinal region disappeared after urination. An intravenous urogram was ordered after Urological consultation. (Figs. 1 and 2.) This study showed an accumulation of dye in a large sac, below the pubes, similar to a diverticulum of the bladder or a hydrocele. Subsequent cystoscopic examination revealed a small diverticulum opening on the dome of the bladder to the right. A catheter passed through for the distance of twenty cms. (H. T. L.) During this examination distention of the bladder distended the diverticulum sac in the scrotum. (Fig. 3.)

The patient was readmitted three months later on the Urological Service. Under spinal anesthesia a five inch incision was made on the edge of the right rectus muscle. (R. M.) The tissues were divided and the mass in the lower right quadrant identified. This mass was very adherent to the external ring and also to the conjoined tendon. The sac was easily separated

\* From the Surgical and Urological Services of the Methodist Hospital.



FIG. 1. Anterior view, intravenous urogram.



FIG. 2. Lateral view, intravenous urogram.



FIG. 3. Anterior view, showing ureteral catheter in scrotal portion of the bladder.

from the scrotum and it was found to be very thickened. By sharp and blunt dissection the sac was found to be a continuation of the bladder. No diverticulum could be noted. The sac at the bladder was opened in order to identify any possible hidden diverticulum. None was present. Therefore the entire mass which had extended to the scrotum was a

herniation of the urinary bladder through the external ring. A small section of the bladder about the size of a silver dollar was resected because of a large amount of scar tissue adherent to it. A Connell suture was placed in the opening and this reinforced with another layer of sutures. The bladder was placed in its proper position. Hemostasis was satisfactory. The external ring was closed. After the removal of the section of the herniated bladder the patient made an uneventful recovery. Microscopic section of the tissues removed showed a portion of the bladder wall.

Before discharge from the hospital a repair was made of his left recurrent inguinal hernia. (C. D. S.) This operation was followed by complete recovery and he was discharged from the hospital. Two months later he was readmitted to the Methodist Hospital on the Urological Service for the treatment of an hypertrophied prostate, discovered during his previous admission. A two stage prostatectomy was followed by an uneventful recovery. (R. M.) Six months later at follow-up examination he was found to be in good condition.

The foregoing is a presentation of what is technically known as a paraperitoneal hernia of the bladder. These constitute about 1 per cent of all hernias found in adults. This 1 per cent represents all three types of bladder hernias: the paraperitoneal,

the extraperitoneal and the intraperitoneal. The paraperitoneal is the most common and the intraperitoneal the least. Those interested in the surgical treatment of inguinal hernias are familiar with the fairly common small paraperitoneal type.

This case has been presented because of the marked advance the bladder hernia had made compared with the descent of the peritoneal sac. It is our opinion that blad-

der hernia as advanced as this represents a small fraction of the 1 per cent bladder incidence in adult hernias.

This case suggests an etiological factor in this type of hernia, namely, the bladder neck obstruction by an hypertrophied prostate.

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It should be noted that the so-called umbilical hernia of adult life does not occur through the umbilicus. It is a protrusion through the linea alba just above the umbilicus or, occasionally, just below that structure.

From "A Short Practice of Surgery" by Hamilton Bailey and R. J. McNeill Love (H. K. Lewis & Co. Ltd.).



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# Bookshelf Browsing

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## CRUTCH MASTERY

The author of this article has been a friend for many years. He did not write the following classic with an idea of publication in any special periodical. He gave the manuscript to another mutual friend, a well known orthopedic surgeon and a member of The American Board. One evening at this surgeon's home, it came into my hands and I asked the author's permission to publish it. My reasons were several: I found it enjoyable reading; it would serve as an invaluable text to any professional crutch user; physicians in charge of government hospitals could use it as a guide when "ordering" crutches for their patients; and manufacturers would make better crutches should they follow the author's tips, based on fifty years' experience. The author, an internationally known ophthalmologist, refused permission to use his name. In fact, in his last communication, he wrote: "I want to emphasize again that I am very anxious that my name is not used." We are certain that our readers will enjoy the following article thoroughly, and we are also certain that it will make life much easier for those who are forced to become crutch addicts.

EDITOR

I HAVE been engaged in the practice of medicine for about thirty years. The old and experienced patient can often contribute to a doctor's better understanding of classic disease by a description of the manner in which he has been able to adjust his pathological self to the environment of these accelerating times. By placing myself in such a patient's position, I thought my own experiences in adjustment might be helpful to my fellow practitioners.

Though I have two legs, one is about as much use as the bobbed tail would be to a cat. It can't be used for balancing nor will it support more than the shoe it wears. My lower back serves only to swing into position what I call my "good left leg" which, because of partial paralysis, prevents me from hopping (at times a very useful form of locomotion). I cannot balance on this leg long enough to start the hop and it lacks the necessary muscular springiness. My arms have been very satisfactory for all forms of gorilla-like exercises though the classical arm reflex the "elbow jerk" (like the knee jerk) is not present. In the past, I could chin myself ten times with one hand and walk about on my hands to the Queen's taste. These

are the maximum necessary comments about me. The rest is about my crutch. My physical peculiarities, not handicaps, are the result of infantile paralysis, the virus of which reached my spinal cord when I was seven months old.

My experiences have been confined, for the most part, to the use of one crutch, with the addition of a cane for about twenty years. The problem of using two crutches instead of one crutch does, to be sure, differ in many instances but in my own experience, when one can use a crutch and a cane rather than two crutches, the advantage in maneuverability is very much worth while. It is very easy to hold the crutch and the cane in the same hand when occasion demands, easier than it is to hold two crutches in one hand. This provides a free hand and a free hand is very useful. When a child, I wore a hip length brace which weighed about one third as much as I did. It slowed me down until I could abide it no longer. I have never fully understood its purpose. I got rid of it as soon as I could fight back and then I began to go places.

The crutch\* has been a friend of man from prehistoric times. It is depicted in early carvings and is often seen in the

\* Webster says the word is Anglo-Saxon in origin.

paintings of the masters of the Renaissance. No doubt, the first hunter used a forked stick to aid him in his homeward journey after being trampled by a bison or bitten by a beast of the jungle. The crutch is thus as old as man and hence is perhaps the earliest agent of medicine. It became an intimate friend and doubtless was personalized as were trees and flowers.

To the initiated, the crutch has sex. It has a right to be classed as feminine as is a ship because it takes a man to manage it. That man is the "Crutch Master." A good crutch is used and abused just like a good wife, neither goes back on you.

There are two kinds of crutch users, amateurs and professionals. Amateurs use a crutch for only a few weeks. Then it is cast aside. It takes practice and a certain amount of cerebral activity to become a Crutch Master. The necessary facility is gained not only in proportion to the extent and degree of the infirmity but in proportion to the interest one puts into the use and abuse of the crutch. A crutch is not a prop but an agent of locomotion, a weapon, a tool and a sports gadget. It has been greatly misunderstood because it is, for the most part, the product of evolution and the handiwork of those who are themselves not Crutch Masters. One must learn the intricacies of its use as one learns the technic of golf, archery or fly fishing.

From my earliest days, defects in the construction of the commercial crutch have been a great source of annoyance and a stimulus to my ingenuity. The usual commercial crutch may be made of birch, which is very heavy but resilient, of hickory, which is apt to be very splintery and which holds the dirt in its "creases," or of maple. Maple seems to be a good wood but it also is very heavy and lacks resiliency. Hickory is resilient and can be made into a reasonably good crutch. The grain of the wood should run the whole length of the crutch. There have been cases recorded where a crutch has broken and because its grains ran obliquely lengthwise, a long spearlike fragment has

penetrated the chest or abdomen of the user. I must have broken crutches very frequently in my grammar-school days because I have a distinct recollection of trying to satisfy a group of my classmates each begging the privilege of going to my home for a replacement the next time I broke my crutch. They stretched the trip into a one half hour each way which meant that much licensed hookey.

Metal crutches have been entirely unsatisfactory. I have tested out tubular steel and various aluminum alloys. Pogo stick like arrangements and springs were included among my useless inventions. Perhaps the post-war period will provide a satisfactory metal or plastic. I doubt if anything will be better than an improved laminated wood construction. Just as it has turned out to be the best for the construction of the modern long bow, so it will make the best crutch.

I have come to the conclusion that the best crutch, at the present time, is made of lemon wood. Lemon wood is commonly used in the manufacture of bows for archery. Its resiliency is very pronounced. It does not break readily but unless properly cured is inclined to split. Slight splits are only superficial when they occur in well seasoned wood and do not endanger the user.

I get my lemon wood from a bowyer who very carefully selects pieces for me. The grain is always true, following the whole length of the billet so that when the crutch is made I have no fear of an oblique splinter. Lemon wood has very fine grain. Speaking about these woods recalls to my mind an incident of my boyhood. I was presented with a very beautiful pair of crutches, each stave being made of two rosewood rods. There were beautiful nickel plated attachments for the hand grip and the top was a soft leather sling. I was a bit on the vigorous side and very powerful in my arms so that it was my custom to vault down a flight of stairs instead of taking them singly. I would place one hand on the railing, aim my crutch at the third

step and then leap forth into space. The hand on the railing would be used as a brake so that when I reached the third or fourth step below the point where my crutch rested, I would put on the brake and light on the step sixth or seventh from the top. After trying the crutches out with much pride, I heard my playmates calling. I employed my usual downstairs technic with the result that the rosewood crutch broke into a hundred splinters and I kept right on down the stairs on my manly bosom. It was not uncommon for me to fall downstairs once in a while anyway because I was too impatient to slow the rapidity of my descent. After reaching the prone posture through one of these mishaps, I would clutch the spindles of the railing. Since my grip was unfailing, it was not uncommon for me to end up at the bottom of the stairs with the spindle in my fist. I never seemed to be badly hurt. I always landed on my hands. They could take it.

In making the crutch of lemon wood, I have the carpenter or cabinet maker split the billet from the top to within six inches from the bottom. The sides, or staves as I call them, are then spread to the proper distance to receive the crossbar or hand grip. In the crutches procured on the open market, seldom is such a technic used. Each stave is usually a separate piece and they are held together at the bottom by rivets. The hand grip is put in by a long through and through rivet and the top is secured in place by two metal pegs. These are inserted from the sides of the headpieces so that when they protrude, as they infallably do, either the cloth of the coat or the cloth of the sleeve is ripped and torn. I have been trying for twenty years to get somebody to put these rivets in the head facing front and back so that when they work their way out they will not damage the clothing. Every joint should be a perfect fit and glued with a waterproof cement and possibly screws. The hand grip should be located at such a distance from the top of the crutch that the arm is slightly bent when the subject is standing erect.

By straightening the arm, this allows the subject to raise himself one or two inches without the crutch slipping from under his arm. This is often a necessary maneuver in negotiating steps and inequalities of the ground. The hand grip should be spindle shape. No effort should be made to adapt it to the shape of the hand because it is very often necessary to rotate the hand and apply pressure from the sides or obliquely. This is particularly so in rising from a chair. The hand grip should not turn on a spindle as such motion soon results in squeaking and undue wearing.

The length of the crossbar or hand grip should be such that the hand can spread fully when pressure is made on it. I have had crutches on which my weight flattened out my hand and caused the sides of the hand and the knuckles to be chaffed in a painful manner. The grip should not be too big around nor should it be too small. One normally holds the crutch with three fingers gripping the crossbar and the index finger running down parallel on the forward stave. This particular grip allows one to move the crutch sideways by the application of the thumb and index finger and at the same time gives good backward and forward motion. The index finger is used very often for carrying small packages, holding gloves, etc. when the other hand is engaged. Hence, an over large diameter to the crossbar weakens the grip on the crutch.

We must keep in mind that though major movement of the crutch is backward and forward, a great deal of motion sideways and obliquely is employed. The hand grip again should be made of lemon wood because a split in this hand grip is not only apt to pinch the flesh but may cause blisters and may lead to a sudden splitting open so that the hand grip falls to the ground. This may cause a fall. I remember this happened to me once when I was holding a suitcase and stepping off a train. I put my whole weight, including that of the suitcase, on the crossbar and it promptly split open and dropped me to

the station platform. Fortunately, this occurred in my more sedate years. The train was not moving at the time. In my youth I regarded it effeminate to wait for the car to make a full stop before I alighted.

The long rivet, which passes through a hole in the hand grip and through both staves, should be of good steel, not of soft wire as is often found in the commercial variety. It should have a nut on one end and a smooth riveted end on the other. One can thereby take up any slack to avoid squeaks. It is inadvisable to try to cover the cross grip with leather or other protecting material as this becomes twisted and ragged and in no time has to be removed.

A metal strap is put around at the lower end of the crutch at the level where the two staves separate. Unless this is put on properly, shrinkage of the wood permits it to slide. A squeaking crutch is so much more embarrassing than a squeaking pair of shoes that one always feels that too much care cannot be taken to guard every point where motion may occur which will eventuate in a squeak. Screws and bolts should be used in the construction of a crutch wherever possible so that as the wood swells and shrinks, the resultant play can be taken up.

I think the most embarrassed hours, they seem like hours, are the few minutes I walk down the aisle and across the stage to lecture before some dignified and expectant assembly when the whole hall seems to vibrate and echo with the squeaks of my protesting crutch. You can't blame this on your wife or secretary or even on the plumber. The best treatment is a preventive soak in a bath tub of water for one half hour. This is usually effective for two or three days. A better way is to have a crutch so well made that it cannot squeak. Packing, washers and oils are useless.

The tip of the crutch or ferrule is a region of utmost importance. The old fashioned crutch was usually provided

with a thimble-like crutch rubber. It slipped directly over the rounded wooden end. Many times this wooden end was sharp edged. If one is to use a market made crutch, he should promptly round off this end, then place a piece of tough wrapping paper in the crutch rubber so that the grinding and boring motion of the crutch comes in contact with the wrapping paper and thus retards cutting through the crutch rubber. There were also screwed in rubbers and some made with canvas inserts but they were very hard and short lived. I once had a pair made of leather plugs which were no good at all after the first rainy day puddle dunking. The modern and only really satisfactory ferrule is composed of a tubular part with an outspreading bottom. This receives a jawlike clutch which grips a knobby block molded of rubber. This rubber contains an outflaring flange which engages a groove in the clutch. I have found it necessary to insert a wire on the inside lip of this clutch to make a better overhanging edge. Otherwise, with rough usage, particularly after the parts are slightly worn, the rubber is inclined to be pried loose. When this occurs, the vigorous user may sustain a serious injury. I remember this happening on a number of occasions when I was alighting from a moving trolley car. One time, when walking up the incline slope of the opera house aisle the rubber popped out and went bumping and bounding up and down towards the stage. It did not land on the stage but doubtless beamed some dowager in the audience. I kept going. To walk home with a crutch rubber missing is like walking home with one shoe missing. It is obviously disconcerting in many ways.

There are a number of other points about the tip of the crutch which are of utmost significance. Unfortunately, the rubber used for commercial crutch tips seems to be made of the most inferior scrap procurable. Very few have any elasticity after they have been on the store shelves for a few months. Such rubbers are very short-lived and are so hard that they jar the

user at each step. I have found it necessary to have my crutch rubbers made to order of the best procurable gum. If a crutch will not bounce two to three inches when dropped from a distance of two feet, the rubber should not be accepted. I was very pleased when I first secured these lively rubbers and was demonstrating their bounce to a portly dignified friend. As I threw my crutch towards the floor to make it bounce, he thought I had aimed it at his foot. I had neatly aimed it an inch or two to one side of his foot but unfortunately he sought that very place for safety. Needless to say, I departed while he was still incapable of biped locomotion. It reminded me of the same trick which I used to play in my youth. I would see how close I could come to my playmates feet with my javelin-like crutch. I called this "making them dance" after the fashion of the Wild West. It was usually effective.

I have found it necessary to change the method of applying the ferrule to the crutch. The commercial variety has a very coarse thread. The wooden tip of the crutch is then provided with a similar coarse thread so that the two may be screwed together. This results in a considerable decrease in the strength of the crutch at its lower extremity. The wood not only has to be relatively small in size, in order to fit the ferrule, but is further decreased in diameter by the cutting of the thread into the wood. On a number of occasions, I have had this very weak place, the weakest in the whole crutch, break off when the crutch became caught in a crack in the pavement. I remember on one occasion while climbing a steep bank from a trout stream this broke off abruptly and promptly dropped me into the water. For that reason, I have the threads removed from the commercial ferrule. The ferrule is then driven on to the wooden end of the crutch and a small rivet put through. The bottom end of the crutch can be split and a wedge driven in, similar to the way a hammer head is put on. This wedge cannot come out because the clutch

which holds the rubber is screwed in against it.

The particular curve of the head of the crutch, the part which goes under the arm, is of considerable importance. This curve should be relatively shallow. It should not dip from the horizontal more than one and a quarter inches. Some makers have a mistaken idea that a very deep curve keeps the crutch from slipping from under the arm. Such a curve may be helpful to some old and feeble persons, who barely move about with assistance and whose muscles are too flabby to support their weight. It is not uncommon for this part of the crutch to be made of wood, which is relatively rough. It shreds into splinters much more easily than one would think. On occasion these splinters have ripped and torn perfectly good suits. It is a mistake to pad the top of the crutch. This is done by the uninitiated in an effort to be kind to the armpit but a serious difficulty arises when this soft material spreads sideways with the weight of the body, thereby having the effect of prying the shoulder joint apart. Of course, the proper way to walk with a crutch is for the weight to be taken on the heel of the hand. Very little weight should be applied at the armpit. Large nerves and vessels run very superficially in the armpit and these are forcibly compressed at every step. When the big nerves are injured, crutch paralysis results so that the fingers and forearm are partially and temporarily paralyzed. When pressure is made on the large blood vessels for any length of time, the hand becomes numb and cold. This feeling is, of course, exaggerated during cold weather. It is best to make the top of the crutch of some good grainless wood. Lemon wood is again a good material. Apple or maple is appropriate. It is often very necessary to whip the crutch from under the arm as when taking a seat, etc. For this reason the curve must be shallow and the wood of glass-like smoothness.

There is no paint, varnish, stain or lacquer which will stay on a crutch long

enough to be worth while. I have even tried to get a dark brown appearance by browning the wood with a hot iron. It was worn off and the white under wood showing within two weeks. Some naturally dark wood with the right characteristics would be ideal in this respect. A well polished crutch painted with one of the modern lacquers is best. A crutch is frequently dented and scratched. It gets grimy and paint streaked from banging and bumping various objects. Wash it occasionally with soap and water.

I have noticed that the crutches provided in hospitals are often made with adjustable parts so that they can be lengthened or shortened to fit the various users. It is no time at all before these crutches develop lost motion. There is nothing tending towards lack of confidence in learning to walk with a crutch more than instability of the crutch. A sudden side motion, dropping or twisting will give the user a sense of imbalance which will easily disconcert him and make him feel unsteady, perhaps in precarious places, as walking downstairs, etc.

The original crutch was a single stave of wood with some sort of crossbar at the top. This has many advantages if it is impossible for one to bear the weight of his body on a crossbar, but the single billet crutch can only be used when the weight is taken by the underarm. Weight distributed in this way is not only bruising to the armpit but also tends to create curvatures of the spine. The ideal crutch should have very considerable spring. At the same time, it must be free from play and lost motion. If the crutch is too rigid, it will naturally jar the user; if it is too flexible it will lend a feeling of insecurity and may be bent beyond its elastic limits with violent motion as when the user is carrying a suitcase or other heavy weight. In testing a crutch for its flexibility, it should bend sideways under the whole weight perhaps one-quarter inch. When descending from a step with a suitcase or something of that nature, it should have a spring perhaps

not greater than one inch. This flexibility in a crutch is a very important factor in preventing fatigue and in the evolution of the necessary activities which one must meet in daily life.

For a man of 150 lbs. weight each stave should be no thicker than one inch by half an inch, and probably could be made lighter for people of sedate habit and lighter weight. Shaping of the staves to distribute strain and attain maximum resiliency should be considered.

Many accessories have been devised for crutches. One of the first to come to my notice was a top or shoulder piece made of flexible material covered with leather. This makes a sort of sling between the two ends of the crutch staves. It is very unsatisfactory as the weight of the body causes the staves to approach each other and has the tendency to gouge the arm back and front. I remember a crutch of this type which was presented to me as being a great boon to my comfort. The side sway and flexibility of the top made for a feeling of insecurity. Being very vigorous in the use of the crutch, it was no time at all before the violent agitations destroyed the flexible top. It tore loose from the ends of the stave and the whole crutch had to be cast aside. Sponge rubber caps for the top are of no help and cause the crutch to stick under the arm when on occasion it is very necessary that it be slipped out with facility.

Perhaps there are more accessories devised for crutch tips than for any other part of the crutch. The greatest demand seems to be for some sort of nonskid device to be used in winter. Unfortunately, there are three or four types of surfaces so that the commercial nonskid devices adequate for one surface are inadequate for others. For instance, smooth ice calls for various lengths of spike depending on the thickness of the ice. Some of the spikes have adjustable pins so that they can be regulated for various depths. If one steps on smooth pavement with a small spike, it penetrates the thin ice. Insufficient

surface for friction is thereby created so that the spike will slide, ripping through the crust of ice. I remember when I was a school boy I had a spike of this nature. It was provided with a thread and a disc to raise or lower the spike. I went into the school and walked across the brand new gymnasium hardwood floor. I noticed something was annoying my perambulations and looking back discovered that I had pulled half inch splinters of wood from the floor where my crutch spike had encountered it at each step. We had all been warned not even to walk on this floor without rubber soled shoes so it took no time at all for me to get out of sight and sound. A spike of this kind is entirely useless in lightly packed snow and it is very dangerous on a smooth, hard pavement such as one finds in public buildings and vestibules. It is not at all popular in houses where one is apt to meet Persian rugs in front halls. It penetrates linoleum and rubber floors in a very efficient manner. Nonskids have been devised in the form of chain-like caps. I used to make them of the old-fashioned steel sink chain. The difficulty with this type is not only to keep it on the crutch but it also accumulates a hard ball of well glazed ice which at times results in a condition which is entirely incompatible with a vertical position.

Leather caps containing small iron hobs such as the mountain climbers wear on their shoes also accumulate pads of packed snow. These hobs have to be placed very close together, and they wear out readily.

Any of the above mentioned nonskid devices are very unpopular in crowded street cars and subways where one may inadvertently place his crutch on someone's foot. On one occasion, in a crowded street car, my sharp spike went clear through a man's shoe, very fortunately missing his toes. It took quite a time getting the two of us separated again. I devised a tube to squirt sand for each crutch step, wire meshed gadgets and even a cap of bear's fur—all no good.

I think I have solved the matter of this

nonskid for icy weather and for wet pavements by a very simple device. I select a cotter pin, which can be purchased in any automobile supply store, and a small very hard steel split-ring about half an inch in diameter, which is supplied by fishing equipment stores. It is very similar to the old-fashioned steel key ring but only one half to one quarter inch in diameter. I slide the ring into the eye of the cotter pin and insert the cotter pin with its limbs slightly parted into the hole provided in the center of the crutch rubber. As one applies his weight, the cotter pin is forced into the crutch causing the ring to tip obliquely from the surface of the crutch rubber. This shakes off any snow or ice which becomes packed during a previous step. As the crutch is placed on the ground, the steel ring digs in obliquely and works its way into the surface. This holds very well on hard ice, packed snow, wet leaves, etc. It is very easily and quickly removed when one has occasion to step on a tile flooring, etc. It is needless to say that this gadget is very inexpensive and one can have three or four in his various overcoat pockets without any undue encumbrance. Crutch tip gadgets are naturally filth accumulators so that the less elaborate they are, the less liable they are to accumulate debris. The commercial spikes provided for crutches are particularly fine accumulators of rubbish. I recall on one occasion in my boyhood days walking down the church aisle and dropping a fine collection of dead leaves off my crutch spike. My grandmother was a bit upset at this sacrilege.

Of course, many crutches have been put on the market with all sorts of hand operated spikes. One variety was devised so that you could pull a trigger which would cause the spike to project from the bottom of the crutch. Such arrangements were not only clumsy, noisy, dirty and rusty but they were continually out of repair and a total loss from my viewpoint.

Numerous benevolent beings have devised folding crutches, crutches with



leather covers, crutches with cloth coverings to match the overcoat and make them less conspicuous. I once saw an old lady who wore her crutch beneath her clothing. She held it by reaching through her pocket. I wonder how gracefully she replaced it after it skidded to infinity when she stepped on the proverbial sidewalk banana skin?

A folding crutch is an abomination and a danger to everybody within a five foot range. Covers on crutches are a delusion and a snare in every sense of the word. They soon get dilapidated looking, they cause friction between clothing and the crutch, particularly when fast maneuvers are necessary and they are easily soiled.

The crutch may be said to have normal and special uses. One should not think of the normal use of a crutch as a simple walking motion. I remember that during World War I, some "devilish orthopedist" devised a crutch with a rocker on the bottom. This was, as I recall, to be used to instruct the beginner in the proper technic of crutch walking, said to be a sort of a rolling procedure. While I never tried one of these crutches, I have often wondered how they were managed in a room cluttered with furniture, with people moving about, on the steps and on slippery floors. It seems to me no one could devise a better means of tripping himself or his fellow men. Only when navigating in a straight line is the crutch swung back and forth like a pendulum. The least turning or twisting, elevation or depression requires that the crutch be swung in or out, further or nearer, twisted or slanted. It is not at all uncommon for a crutch used on the right side to be applied to the left of the midline of the body. Unusual positions are not uncommon on rough ground. When stepping up curbs, down in depressions, over low obstructions, turning sharp corners and during the transportation of packages, etc. one has to use many variations from the usual. When I was a school boy I had much more occasion, of course, to notice these unusual complications than I have

since I have become more sedate. It was my delight to get off a trolley car when it was going at a good clip. I prided myself that I could get off the moving car faster than the able-bodied men. Under those conditions (always facing in the direction of movement) the crutch hits the ground first at the same instance that the car handle is released. The body is then swung forward by the motion of the car. The crutch is then whipped around in the direction of movement and a perfect two point landing results. This is probably not nearly as dangerous as it sounds after one has attained the necessary skill because the base on which the subject alights is perhaps five or six feet long, that is, from where the crutch first hits the ground to where the foot first hits the ground. It is more difficult to get on a moving car than it is to get off because there is no opportunity to use this wide landing base. One simply grabs the passing handle, swings his foot on to the step and if his grab is good he does not get snapped on to the floor of the car too fast. On one occasion, I was standing on the back platform of a trolley car right near the step. I had some books, which I was holding and which occupied my unengaged hand. A dignified lady brushed past me and stepped down on to the ground. The car started but to our mutual chagrin, we promptly discovered that a piece of braid on the bottom of her dress had caught on the hook of my shoe. I was in such a position that I could not bend over to unhook this braid without falling off into the street. The car started before either of us could make a move. Fortunately, cars gained momentum slowly in those days. I remember the expression on the lady's face as she slowly turned around with yard after yard of braid unwinding. Needless to say, this was in the days when ladies skirts were long and well braided. The car proceeded down the street amid the gleeful howls of the back platform gang.

One of the most dangerous things, at least in the old days, was wet asphalt pavement. I did not realize for years why



this should be so slippery to a crutch rubber. After I studied medicine, I realized there was a relation to horse manure on the street, that the mucous from the horses' intestines and the gummous starch of the oats forms a thin layer covering yards of pavement. This was washed out by the rain. Many an unceremonious spill have I had into a nice pile of horse manure. One learns after a while to step on the uphill side of such good fertilizer as the rainwater spreads the slime downhill.

Wet and rotting leaves are other slippery things for a crutch when they form a thin layer on the pavement. Smooth steel surfaces as car tracks, manhole lids and cellar doors and marble are bad when wet.

Other dangerous places which the city man meets in his ordinary perambulations, are the subway and cellar gratings which sometimes encroach on sidewalks. Years ago the openings in these gratings were of sufficient width so that a crutch could pass through. On a number of occasions, my crutch went through the space between the bars of the grates and my whole weight came down on my knuckles. If it had not been for the fact that I was so light, I believe I would have broken all my finger bones. Only once did my crutch go through entirely but it landed in a shallow areaway so that I was able to fish it up with some string and wire such as a boy is apt to carry in his pockets. Such gratings will sometimes grip the crutch rubber and twist it from the ferrule.

Among the more unusual uses of a crutch can be listed that of a ladder, a weapon, prop and a hook, a vaulting pole for puddles and in my youth a sling shot. Being raised in the city in the days when backyards were enclosed by six foot solid wooden fences, the crutch was of good use to "my gang" as a ladder. I would approach the fence, place one hand on the top of my crutch. The gang would give me a boost until I could reach the top of the fence with my free hand. I would then raise myself above the top of the crutch until I could swing a leg over the top of the

fence. I would then leave the crutch against the fence. The rest of the gang would put one foot on the crossbar, one foot on top of the crutch and pull themselves up. The last man would hook the crutch up with his foot. Four or five of us could proceed down the block with reasonable celerity if there were no dogs or similar joy killers to impede the progress of the "Indian file."

I was very sensitive if anyone accused me of using my crutch as a weapon but I must admit I did so on one or two occasions when my gang was getting the worse of it. My best method was to drop to the ground and use it as a scythe on shin bones. If one really has to use a crutch as a weapon, the best way to do so is to stand close to the opponent and then whip it out from under the arm and use the upper end as the soldiers use a gun butt. Bring it up good and fast under his chin or catch him in the eye, if you are man enough. As a youngster, my technic in a rough and tumble was to dive at my opponent's legs below the knees, a heave with my shoulder and one or sometimes more of them would be down so that they no longer had the mobile advantage of me. I was strong enough in my arms to handle all I could get within reach in a sort of mugging all embracing grip. If you try to use the crutch to swing or poke, it is soon grabbed away from you and then you are more helpless than ever. Do not hurl it as a javelin as John Silver did in Stevenson's "Treasure Island." You might miss and it is not heavy enough to knock one out unless you strike a vulnerable spot.

Very rarely will the movements of your crutch arouse a dog's ire. Do not try to strike at him with it as he is much too fast if really attacking. As a defense measure, point the end at him but better yet keep it by your side and order him away in your well known rough commanding voice. If you are smart enough—and I was on but one rare occasion—catch the dog's head between the staves in the lower part of the crutch, then shove down on his head or

neck, thereby choking him in the V where the staves come together. One must be careful in playing with dogs that their paws or heads do not get caught in this trap.

The crutch is very useful as a prop, depending on circumstances. It can be jammed under the handle of a door and against an opposing piece of furniture in case one wants to be sure the bedroom door is not opened in some strange hotel.

The bottom V formation can be used as a boot jack and I have used it as a sled on a well frozen bank.

During my internship it was one of my duties to escort "drunks" from our hospital to the alcoholic ward of the County Hospital. There was a wide polished leather covered seat across the back of the ambulance. I would sit lengthwise with one arm through the leather sling to keep from being thrown out. My crutch served as a shover backer when the drunk endeavored to rise from his couch. On one occasion I had just completed this persuasive act when the old bus dove around a corner. The wheels dipped into the sewer depression. As I grabbed for more support, the crutch shot out and into the sewer opening. Fortunately it jammed there and some urchins deemed it a great favor to retrieve it for me, though they had to run after the ambulance for a block or two as the ambulance driver thought my shouts for him to stop were part of my conversation with the drunk.

The crutch can be used as a hook to reach various objects. It has served as a hook in climbing up the bank of a trout stream and as a boy it was convenient to hook the overhanging part of the crutch head into the tailboard bracket on a passing wagon when I wished to get a hitch on my sled. This was not always satisfactorily accomplished.

My brother and I used to go sleigh riding by another means. He would go down the street a block and hook his sled on to a passing vehicle. I would be watching as the trotting horses passed, would

make a dive for the sled, reaching for it with one hand. He would grab my extended crutch in the other hand and with the wet slush penetrating my clothing, we would manage between us to drag me on shipboard.

When one has occasion to carry packages, an effort should be made to see that the packages are bound with strong cord so that the fingers can pass through the cord and around the hand grip of the crutch. The handle on a satchel should be thin for the same reason. If it is too plump, one cannot grab the crutch securely and the satchel handle at the same time.

The V of the crutch is not a bad gadget to draw down an uprun window shade. The ring or knoblike tassel of the dependent string is coaxed into the V where it catches and is easily drawn down. Be sure your balance is good, otherwise the window pane may suffer, a not unencountered catastrophe in my experience. The crutch rubber retains a charge of static electricity on many occasions so that it can be used to pick up tissue paper, etc.

#### CLOTHES OF THE CRUTCH MASTER

There are less obvious points which are of importance. One is about the type of clothes best adapted to use with a crutch. In having a suit made or altered, have a shield placed under the arm of the same cloth of which the suit is made. This cloth should be cut on the bias as it then conforms better to the shape of the armhole. One is to caution the tailor not to put a seam in this shield as otherwise a heavy ridge of material is formed right where the crutch presses, as the seam of the shield usually falls where the sleeve and the body of the coat are sewn together. A leather patch or shield is, without doubt, the most satisfactory but it looks like the devil, particularly after it has been used for some time. I have had many a fall when the crutch head has become tangled in a shield. The stitching wears out and the shield then forms a beautiful pocket in which the crutch becomes well entangled. In descend-

ing a flight of steps or in attempting to sit down, the crutch must be whipped from under the arm with dispatch. When this act is not accomplished with smoothness, it projects the crutch user obliquely and backward, sometimes with embarrassing consequences, as in church or theatres. The arm on the crutch side of the sackcoat or overcoat should be made as small as is conveniently comfortable. A large armhole results in the coat being elevated by the crutch head and an awkward bunch appears above the shoulders. For this reason, raglan cut overcoats seldom present a good appearance, armholes in such coats being rather large. A sac coat made with enough flexibility across the shoulders is desirable so that the movements of the shoulders incident to the use of the crutch do not drag, pull or stretch. It is important to have coats provided with patch pockets. The thumb of the crutch hand wears through the heaviest cloth as it moves back and forth with each step. Hence many a good suit has been ruined long before its time was up when patch pockets have been omitted. As soon as the patch pocket wears through, it can be replaced. There should be no usable pockets on the side of the crutch as objects in these pockets are very apt to interfere with the motion of the crutch. They should be sewn closed. This detail was neglected on one of my overcoats and a considerate friend placed a bag of squashy candy in the pocket as the clothes hung over a chair. I had taken one or two steps before I discovered the mushy mess which had interfered with the movements of the crutch. Fish hooks are not well tolerated in pockets on this side of the coat. Inside pockets are to be avoided entirely. Extra pockets can be placed on the opposite side of the coat for change, fountain pen, etc. An inside coat belt is useful.

I have found it much better to avoid linings in all coats as much as possible. These linings get twisted into kinks and wrinkles which soon cut through the material.

Suspenders are sometimes a source of annoyance as the crutch often hits the buckle, particularly on the man-sized braces which were more common in the old days. The buckle can be removed on the crutch side and the webbing sewn together. The suspender buttons are not good, the clip or snaps on modern suspenders allow the removal of buttons. A belt is a good thing, the wider the better, because the crutch has a tendency to twist the clothes around the body. A snugly adjusted belt prevents this torsion. It is said that both belt and suspenders denote a pessimist. Remember, if you do not know it already, that a tight belt gives some folks indigestion.

Overcoats should not be longer than knee length. The longer the coat, the more it flaps about the crutch and impedes its use. If the coat is to be longer, as a raincoat, it should be of light weight material and have an inside belt.

I have found the greatest difficulty in securing the proper material from which to make a suit because a very hard finish will be polished to a glass-like luster by the movements of the crutch. A suit with a long nap soon shows bald spots. I have found the best cloth is a tweed of not too loose a weave. Loose weave goods are so yanked and twisted that they soon develop holes. Covert cloth is fairly satisfactory. One must avoid serges and all hard finish goods. Dark colors show a shine earliest. Light colors are to be avoided because no matter how careful one is, the crutch may leave marks. White flannels are out altogether. Silk threads and stripes soon become startlingly prominent. The best pattern is the so-called pepper and salt of medium darkness.

Sometimes a jacket or overcoat will wear quite thin before it comes to your notice. On occasion, it has happened that my thumb has suddenly gone through a weak place, causing me to stumble.

Leather gloves are the only satisfactory gloves to use with a crutch. If woolen gloves are worn, the crutch hand becomes

clumsy and it is difficult to maintain a firm grip. In really cold weather, one can wear leather gloves over woolen gloves.

One of my clearest recollections of what might be called crutch embarrassment occurred when I was in school. It was in the days of floor sweeping dresses. The well-bred young lady was taught to glide, not walk. We were having a reading lesson, the teacher wandering about the room, book in hand, calling on one and then the other to read. I heard my name called and whipping my crutch up from the floor, I swung its head out into the aisle with an upward motion. An ear splitting scream was the first intimation of the teacher's proximity. I had caught the crutch under the bottom of her dress as she approached from behind me. Yes! This was about Spanish-American war times and believe me it was an embarrassment from which neither I nor the school recovered for weeks. In fact, I have not recovered yet. At least, the adventure got me the last seat in the row. This experience, and similar ones, taught me to make a rapid survey of my environment before rising from my seat in any public place.

I usually pick an end seat in the theaters, and slide my crutch lengthwise under the row as I sit down. This has to be done cautiously so as to avoid things such as hats and footless shoes, which are stored there. Doubtless, I have been responsible for many a frantic search for a size six pump which had been slipped off a size eight foot. Happily I am not there when the scrimmage starts.

Head waiters seem to take a delight in pouncing on my crutch the minute I sit down. It is their idea to place it somewhere out of everyone's way and thoroughly out of my reach. I facetiously threaten to bend it around their starched necks if they touch it, reminding them that in case of fire they would think of me last, if not too late. When possible, I select a table in any eating place where the crutch may be placed against a wall or pillar. Though the floor is always convenient, it en-

courages waiters to spill soup. When it is necessary to place the crutch on the floor, as at a long banquet table, be sure to put the leg of the chair between the staves. Then no one can kick it down the length of the room, inadvertently or in fun. If placed against an adjacent chair, it will sooner or later be jostled to the floor with resounding clatter, perhaps tripping someone in its passage. This can be brought about purposely to rouse a soporific lecturer.

When riding in trains and buses, a crutch is often of less inconvenience than would at first seem likely. I get a seat near the door when I can and place the crutch obliquely against the wall securing it by pressure of my shoulder. It may, on occasion, be held solidly vertical so that a companion may rest his hand on it as he stands.

I have often thought that in case of a train wreck the rubber could be removed and the crutch then used as a battering ram to break the heavy glass window, for escape. I hope I never have the chance to try. It works fine through glass usually found in houses. Not that I am a house-breaker, just found out in some sort of boyish escapades.

There are numerous places which seem to have been designed by man and nature to trap the unwary crutch. The casual rug reposing expectantly upon a polished hardwood floor is the most common. When the crutch hits this, on a slant, one might as well be on a sliding pond. The crutch and rug go one way in a hurry and the crutch master goes the other way but mostly down. Take short steps on any slippery surface as the crutch is then more perpendicular. Also keep it near your mid-line.

There are places where glass is used on sidewalks to admit light to cellars. This is sufficiently thick to resist even the heaviest ice spike but sometimes these round or hexagonal blocks of glass are missing from their metal rims. A beautiful crutch trap is thus formed for the unwary. On a

number of occasions, my crutch has plunged into one of these and since its lower parts are V shaped and springy, it has become wedged. It is only necessary to squeeze together the sides of the crutch and pull upwards to release it. Before stepping from the rainy streets onto a highly polished decorative cement and stone floor (terrazzo) give the crutch rubber a sliding wipe or two under pressure in order to dry it as thoroughly as possible otherwise it makes a slippery contact with the floor and moreover leaves a conspicuous trace of disc-like prints across the floor.

The classical revolving door, which one meets in public buildings, is a nuisance for the crutchman as it is for anyone carrying a bulky object. There is usually an accessory swinging door to one side which may be used. Try to pass through the revolving door near its wide periphery so that the swing of the crutch can be as wide as possible. Avoid the use of such doors when others are using them. Doormen are very attentive in watching your progress. On one occasion, a young man rushed out of the hotel through the revolving door just as I had entered from the street. He gave the door a vigorous swirl but it was jammed to a sudden standstill by my crutch rubber. We had some intra-door sports for a few minutes. Subway turnstiles should be entered with the crutch first. Don't give it an extra spin to get it set for your crutch as this costs you an extra five cents to get the turnstile unlocked again. When anyone holds a door open for you, it is often easy to jam the door open by putting the crutch tip against it. A little agility on your part will avoid a collision with your dorsil fin.

As already implied, sidewalk gratings form another crutch trap and the sewer openings at street corners. When in the fields and woodlands, various holes and interspaces between roots are bad business for the unwary. I have looked up and seen my crutch jammed vertically in a hole made by a woodchuck as I continued end over end down the hillside.

A classical crutch trap, which is well hidden, is a decayed board on a porch floor. These boards usually break either when one is in a particular hurry or is lugging a heavy article of some kind. Once in a while a board is insecurely nailed and if stepped on beyond the edge of the floor beam, will tip up like a see-saw. I remember when I stepped on a newly laid hardwood floor. The careless electrician had not completely laid the underfloor so my crutch went through the thin hardwood layer and through the ceiling of the room below where it protruded five or six inches. It was quite a job to unwedge the crutch from the springy lathes. On another occasion, about three o'clock in the morning, I was walking on an elevated plank walk which crossed a swamp in the Adirondacks. Quite a pack on my back made the weight a little in excess of my usual poundage. I went through this walk and my crutch dropped down about three inches into a two feet layer of mud and water. The rest of my group had gone on so that I put in a swearish fifteen minutes trying to fish up my crutch. I remember the mosquitoes were also on the watch to add to the entertainment.

The hardest places to manage a crutch are deep grass or brush, deep snow, more than three inches and mud. Whenever the crutch has to be lifted more than an inch or two to free it from the encumbrance, walking is laborious and slow. The most mud I ever got into was in the bottom of a lake where I was snooping around in a Beebe diving helmet. It was a mixture of silt and clay. Fortunately, it was quite easy to kick loose as the buoyancy of the helmet was enough to sustain most of my weight. Another tough place was a swamp covered with waist high swamp grass.

A crutch is seldom an inconvenience on a boat, be it large or small. Its rubber tip is not hard on the well kept deck and there are many convenient stowage places. In a canoe, it is often useful. It can be used for poling in shallow places and on one occasion when a paddle broke, it was forced

into service. A heavy bandana handkerchief bound firmly about the arm end converted it into a paddle and quite an efficient one at that.

Contrary to what one might expect, most of my crutches sink when dropped overboard in deep water. There are, of course, exceptions. They sink because of the heavy metal tip, band and handrest rivet. It is a smart thing to carry a bit of cord to use as a lashing.

When fishing in a rushing trout stream, I provide an elastic cord. These can be had in sporting goods stores and are ordinarily used by the fisherman to secure his net to his person. It is well that this cord be elastic as it is often necessary to use the crutch as a wading staff or alpine stock. The rubber then stretches as the crutch is extended at arm's length.

It is of vital importance that the crutch be secured in some manner as in the excitement of landing the *usual* three pound trout, it may slip from under the arm and be carried rapidly down stream. I loop the rubber cord around one stave of the crutch near its top, the other end is clipped to a ring in my fishing coat. The best clip is made of brass and is the ring-shaped type found on dog leashes. I have thus far not had a crutch washed away from me while wading in the trout stream but I have had it slip off a high bank into a pool. A little fancy casting with well leaded line retrieved it on one occasion but I had to jump into the icy water after it on the other occasion.

Trout stream wading is not difficult with a crutch. In fact, I have only fallen twice in twenty years of such fishing. When this happens in deep, swift water, and one is being carried downstream, there are no complications. It is only necessary to keep facing downstream when pretty soon the boots and crutch hit the bottom. Heavy boots are not heavy when completely submerged and there is seldom occasion to swim. The arms are enough to swim with anyway. Getting up on the bank with boots full of water is a tough job for any-

one. Don't try. Sit with your legs in the water and remove the boots there. The rest is a matter of drainage for you and the boots.

The crutch needs a special adaptation for stream wading. I have the cobbler make a leather boot for it. This extends high enough to meet the parting (V) of the crutch staves. The bottom of this heavy leather (sole leather or a little lighter if you like) is outflared and sewn to a 2½-inch disc of the heaviest chrome tanned sole leather. To this a second and similar disc is sewn. The first disc should never be permitted to wear. It is the base on which new outer discs are stitched. A heavy brass screw (round head) is passed through the bottom center of these discs so that it can engage the hole provided in the center of the crutch rubber. This whole crutch boot is laced on the crutch with raw hide belt lacings, which can be purchased in any hardware store. The last turns of the lacings are made fast through the V where the crutch staves meet. This boot will not be pulled off when withdrawn from deep mud.

It is not at all necessary to carry a lot of paraphernalia when trout fishing. If you insist on taking the fish home, do not buy a clumsy creel. Buy a large net such as is sold for landing net handles. This is used as a bag-like creel and is closed at the top by a long cord. It is stored in a pocket or down the top of your boot. I find that this is a very good device when wading as I put my fish in it and drag it behind in the water. This keeps the fish alive and in good color though they do take some banging on rocks and occasional scratching in bushes. I carry no net as any size fish can be landed by hand. Of course, I have lost lightly hooked fish by this method but anyone loses fish even with a net. It is only necessary to play the fish until they are thoroughly tired. They are then grasped through the gills by the thumb and index finger. There is a knack to this whole procedure which a little experience will develop.

Omission of the creel and net, particularly the former, greatly reduces the "impedimenta." I fish each section of the stream thoroughly. This avoids walking, does not decrease the pleasure and permits detailed study of nature. I use a seat cane to wade with besides the crutch. The cane has a spike and a 2 inches chrome leather disc 2 inches from its bottom. I sometimes sit on the cane when casting. When walking, the rod is held vertical to the crutch or horizontally if the distance is great; the handle forward when passing through brush or climbing hills; the tip forward on the clear level. I hold it by two fingers, away from the crutch so it will not get scratched. When standing to tie on a fly, I put the handle of the rod, including the reel, down my boot top. I can take a few steps, if necessary, with the rod in this position.

When climbing a hill from a trout stream, ascend obliquely keeping the crutch on the downhill side, the cane on the uphill side. The crutch has no knee or elbow, the cane has where your hand meets it. You can climb straight up a very steep hill as the crutch keeps you from falling backwards. This method of ascent is hard work, however, but often the shortest way home.

When firing a gun of heavy caliber, I find it wise to place my crutch well away from the gun butt. Once I neglected this precaution when firing a 45-70 rifle. Result, a well bruised arm where the gun kicked, pinching a good fold of skin against the head of the crutch.

It is difficult for me to fire a shot gun when standing as I cannot place my crutch so as to get good support for the kick. The first time I tried this, we were shooting what used to be called "clay pigeons." My friend handed me the gun. I let fly with one barrel. It kicked me over backwards. My friends were just out of reach to catch me. I had both hands full of gun. Naturally, they wondered where, when and how the other barrel was going off. I had it in mind too so I just dropped my crutch, which was ready to fall anyway,

bent my knees and rolled backward to the ground, keeping the gun barrel pointed skyward all the time.

Swimming is one place where the crutch has no place and yet it caused the most inconvenience. It is a tough gadget to manage on a spring board and is better left on the dock. If you dive with it tied on, you are apt to have it hit you or if not tied on you must retrieve it. It is awkward to carry into the surf as someone has to carry it back to land and fetch it when you need it. Stick to a boat or dock for your plunge, where possible. Tie it to a lifeline or float if you take it along.

The crutch is strapped to the horizontal bar on the bicycle. It sticks out before and behind but is not in the way. I remove the coaster brake as I can only push down with one foot and the other pedal will not rise. I have tried springs, pulleys and cords, etc. to bring the pedal up but find it is easiest to use a hand brake and no coaster attachment.

I was scorching along at a good clip one day, age ten or twelve, keeping close to the curb, intent in passing some sort of a horse drawn truck. The driver entirely oblivious of my existence suddenly turned into a driveway, thereby cutting me off. In order to keep from hitting the truck, I naturally cramped the wheel and endeavored to follow in to the driveway beside him. My bike started to skid but at the crucial point my protruding crutch poked the horse obliquely in the side. There was just enough spring in his ribs to straighten up my bike and start me down the sidewalk in the direction opposite to that in which I had been riding. I was never so astonished in my life, that I had avoided a bad fall and I'll bet the driver is still trying to figure out what happened, where I came from and where I went to. I wonder if he had ever heard of Don Quixote's tilt with the windmill.

Keepers on the golf course do not like the neat round holes which the crutch punches. Tennis courts are not happy when they see a crutch coming.



When horseback riding, the crutch is carried like the cavalryman's carbine, sloping under or behind one leg.

I have long made it a point not to rise when a lady enters the room or when I am being introduced, as it usually embarrasses her considerably. People tip you over when shaking hands if they have to reach forward. Shake with your left hand, if necessary.

I nearly lost my crutch on one occasion when I was up in a balloon. It was one of those country fair balloons; hydrogen inflated. A strong wind was blowing and it rose in jerks and short snaps. The shallow basket was tipped to one side so that it stood at an angle of  $45^{\circ}$ . I was holding to the ring to which the balloon net was tied. So with my feet in the basket, I was therefore suspended almost horizontally and practically over the empty space between the ring and the basket. My crutch began to slip out of the basket. Between puffs of wind, I managed to drop into the basket and landing on the the crutch saved it from a thousand foot drop. Yes, I was scared. I was about sixteen years old. There was a boy laying flat in the basket. When it tipped up edgewise, he began to cry. It made me angry because I was in a much worse position than he. I remember hollering "Shut up, you, I am not scared."

Can a one legged man with a crutch slide down a rope as in case of fire, etc? I learned the answer when I was in my early teens. My brother and I were supposed to go up to our room after lunch to work on some catch up studies (a nice way to say we had flunked). The woods called, however. We uncoiled the one inch "fire rope" and dropped its end to the ground. The other end was secured through its staple in the floor. We were ready to descend. My brother twined the rope well around one leg in the well known and classical manner and clamped it tightly with his other leg. He slid slowly to the ground with dignity and unblistered hands. I dropped my crutch to him and preferred to descend

hand over hand, which I could do with ease. I suddenly conceived a new method. A one-legged man gets a bad hand burn if he has to slide down a rope wrapped around one leg as he cannot prevent the rope from unwrapping by pressure of a fellow leg. I drew up about four feet of the rope in order to make a loop. I placed my good foot in the loop, held to the rope with my left hand and clasped the ascending and descending limbs of the rope with my right hand. By relaxing the grip of my right hand and easing myself down with my left, I caused the loop to slide under the arch of my foot. When I had descended some few inches, I tightened my right hand grip and rested my weight in the loop while I secured a new and lower grip with the left hand. By repeating this cycle, I descended slowly but easily. The effect was a sort of slight hitching movement. When I wished to ascend, I merely pulled myself up a couple of inches with a quick jerky motion of the left hand and I took up the slack of the rope with my right. I found my experiment so interesting that we nearly got caught because of the clatter I made against the side of the house. My discovery enabled us to get back in the room with our woodland trophies without laborious effort. It seems to me that anyone handicapped as I am should try this out as it is certainly stimulating to self confidence.

I could add a codicil about my experiences with a crutch on motorcycles and automobiles, particularly on arrangements in driving automobiles. This latter has become unnecessary since the advent of the so-called automatic clutch. Sailboats and motorboats are no problem if one uses his head. Anyone can swim very well if he can move his arms at all. He usually has a big advantage of less weight in his legs. For instance, my legs are so light that I can float indefinitely even in fresh water.

Now all these recitations of my crutch adventures might seem rather frightening to the timorous but the reader must recall that it has taken me fifty years to accumu-



late all these experiences. Most of my misadventures were really due to the natural recklessness or mischievousness of youth and I am well satisfied that they kept me from feeling my handicap (developing complexes, if you like).

I suppose I have given the impression to some that my folks must have been very careless of my well being. Quite the opposite is obviously true if you have read between the lines. My mother was in fear and trembling every time I appeared the worse for wear but she knew by motherly instinct while the psychologists were learning the hard way that she must encourage me to go along with the "Boys." I recall her telling me to get started early to our back lot "rough house" so that I would not miss out on the fun. At that time I

perambulated on hands and knees only with leather knee pads and metal caps on my shoes. I realize now she awaited my return in tears not even daring to look out of the windows.

There is much set down in the above which airs my colossal conceit in accomplishments. I have never felt this conceit in actual practice because I have never felt self-conscious about it. I have never felt any lameness because I have been able to keep up my end. This was only possible because of the attitude of my friends and the environment in which I was raised. There was never any popular effort obvious to me to favor my physical handicap until I was well along in adult life. That is what I am most conceited about and thankful for. I hope others get the same chance I did.



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# The American Journal of Surgery

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## Editorial

### SCARCITY OF NURSES AND HOSPITAL COSTS

**W**E read that living costs still are going to rise somewhat. Farm products, at wholesale, are up 159 per cent since 1939. Food is up 129 per cent in the same period. Since before the war building materials have risen 91 per cent. In the same period textile products, at wholesale, have gone up 94 per cent.

Recently registered trained nurses have received a substantial rise in pay. Anyone who knows the facts agrees that they received what was their just due. But the item of increased pay of trained nurses, plus the increased cost of food, medical supplies and the increased wages of civilian employees have about broken the budget-back of many hospitals. Just recently one large voluntary hospital had to add \$60,000 to its budget for the increased remuneration of the nurses. The hospital is filled to capacity. Its staff physicians have trouble in reserving beds when needed; yet to keep out of the red too deeply, the cost per day per patient has been going up steadily. Ten years ago a semi-private bed that cost \$4.00 per day now costs \$8.50; a private room that originally cost \$10.00 now costs \$18.00 or \$20.00. Nevertheless, with these increases in income the business office is having severe headaches.

Even though they have been granted marked increases in pay the scarcity of

trained nurses is marked. They have been attracted to the Veterans Bureau, the Armed forces and to industry. Even special duty nurses who receive \$10.00 for eight hours of duty, plus their hospital board, are hard to procure at times.

Therefore, pleasure was evidenced in many quarters when we heard that the American College of Surgeons had approved of nursing attendants, nurses aids or the so-called practical nurse for hospital duty. It is hoped this will fill a need that somehow just must be filled. Inasmuch as most States require that a candidate for the degree of Registered Nurse have at least a high school education (and many insist on one language, chemistry and physics), and because the course of training covers three calendar years, many young women have turned and continue to turn to other fields for careers. Training school registration has taken a decided drop. When a patient is acutely ill he must be cared for by a trained nurse; but from observation and experience, we cannot see why the ministrations of a trained nurse are necessary during the usual period of convalescence. Surely anyone possessed of fair intelligence and common sense can wash and powder a patient, attend to his bed pan, carry the food trays, get drinking water and do the many little chores that

make for comfort; and these duties (plus endless paper work) make up the majority of work hours.

Women given short courses in practical nursing and then paid an adequate wage will fill a great hospital need. Speed the day when it is put into operation!

During the War the American Red Cross trained nurses aids at a cost of about

\$40.00 per aid. Without these public spirited women working in our hospitals without remuneration, things might have been chaotic. But aside from the fine work they rendered they proved that an intelligent person with a little training can assume a great part of the nursing load of a hospital.

T. S. W.



*Books and World Recovery.* The desperate and continued need for American publications to serve as tools of physical and intellectual reconstruction abroad has been made vividly apparent by appeals from scholars in many lands. The American Book Center for War Devastated Libraries has been urged to continue meeting this need at least through 1947. The Book Center is therefore making a renewed appeal for American books and periodicals—for technical and scholarly books and periodicals in all fields and particularly for publications of the past ten years.

The generous support which has been given to the Book Center has made it possible to ship more than 700,000 volumes abroad in the past year. It is hoped to double this amount before the Book Center closes. The books and periodicals which your personal or institutional library can spare are urgently needed and will help in the reconstruction which must preface world understanding and peace.

Ship your contributions to the American Book Center, c/o The Library of Congress, Washington, 25, D. C. freight prepaid, or write to the Center for further information.

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# Original Articles

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## MANAGEMENT OF EXTENSIVE COMPLETE DEFECTS IN LONG BONES\*

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TORONTO, ONTARIO

ONE of the most challenging problems in orthopedic surgery has been the replacement of extensive defects in long bones. The many serious residual injuries resulting from World War II has necessitated evaluation of old principles and if possible, establishment of improved methods. A significant defect of bone rarely occurs without considerable damage to associated structures. This may include skin, nerve and muscle; often there is involvement of all the soft tissue. Bone reconstruction should not be undertaken until the damage to these associated structures has been properly repaired.

*Infection.* The structures in such a damaged limb have been grossly traumatized and devitalized, leaving a situation in which further trauma may lead to reactivation of dormant foci. In addition to the risk of possible reinfection, new foreign material will be necessary for sound repair. The reconstruction will need large cortical grafts which are not easily revascularized, and this results in an additional strain on the protective mechanism of the area. The policy of delaying before definitive operation is undertaken has been the subject of such discussion, yet regardless of modern chemotherapy, it is believed that all evidences of infection should have disappeared for at least six months before extensive reparative procedures are undertaken. Even after such an interval, it is not an uncommon experience to find small pockets of infection and sequestra at the time of such an operation.

*Consideration of the Skin.* Poor skin covering can be the cause of many failures. Whether the area has healed by primary intention or by granulation, it will have done so at the expense of bone and soft tissue, producing a contracted depressed scar. When the replacement of lost bone is undertaken in such an area, there will be a resultant increase in the circumference of the extremity. Unless due allowance is provided for this increase in girth, closure of the wound will be difficult or impossible.

Poor blood supply of the area will further jeopardize the healing of the skin. A thinly covered area may break down with disastrous loss of the bone grafts, no matter how well the internal reconstruction has been done.

The exposures necessary for reconstruction are extensive and attention must be paid to devitalized adjacent areas as well as to the defect. For example, the operative incision may heal well but a devitalized scar on the opposite side of the limb may slough, precipitating failure.

For these reasons, it is of the greatest importance to assess skin vitality carefully and repair the damage by full thickness grafts, either by the sliding or pedicle methods, before proceeding with bone reconstruction.

*Vascular and Nerve Lesions.* Many cases with complete shaft defects have also suffered damage to nerve and vessel. The vascular occlusion as a rule will have been relieved through collateral circulation by the time reconstruction is to be considered.

\* From the Orthopaedic Division, Christie Street Hospital.

TABLE I

TYPE OF GRAFT	METHOD OF FIXATION	WEIGHT SUSTAINED BEFORE FRACTURE
Inlay	Twisted Wire	12 Pounds
Inlay	Tied Wire	42 "
Inlay	Vitallium Screws	52 "
Diamond Inlay	Tied Wire	6 "
Onlay	Vitallium Screws	90 "
Dual Onlay	" "	196 "

Nerve injuries, however, need further treatment. During World War I and the early part of World War II, the tendency was to treat the bone as the primary procedure, leaving the nerve until later. Experience at our hospital indicated there are many advantages in first dealing with the nerve and then the bone. The reasons are as follows:

1. Early exploration and suture of the nerve may be done with less danger of activating previous infection. Less rugged manipulation is necessary and introduction of foreign material is of a minimum degree.
2. It may be necessary to take advantage of the gap or shortened extremity to allow an end-to-end suture.
3. There are certain locations where preliminary transplantation of the nerve will facilitate subsequent bone reconstruction. For example, in defects of the lower shaft of the humerus, the radial nerve repair may be done and the nerve transplanted anteriorly, leaving the field completely free for subsequent grafting of the shaft.
4. We now know that early suture of nerves is beneficial. The nerve may be sutured and regeneration then continues while one awaits the lapse of an adequate time following infection of bone. By such a routine, the patient will be saved many months of time and the chances of regeneration are improved.

**Choice of Graft.** Having satisfactorily solved these preliminary problems, the

surgeon is frequently still faced with a difficult task in bridging a gap. The further management of these cases then involves the consideration of the type of bone graft and methods of fixation to be used in such circumstances.

In selecting the type of graft, the histological process of bone repair must be kept in mind. The fate of the graft has been a controversial subject for a long time but it is apparent we must expect that the greater part of bone which is cut free from its circulation will die and become absorbed and replaced. The portion of the graft which survives is small, but it can be a most important contribution to the process of regeneration. Surface cells bathed with lymph may survive, while those in the lacunae become necrotic and die. The open Haversian canals are infiltrated by capillaries accompanied by osteoblasts and dead bone is excavated. As the vessels progress, there is a creeping substitution by new cancellous bone. It is difficult to say definitely which cells and what percentage of cells in parent tissue are responsible for ultimate union. Under different circumstances, participation may be in different degrees, similarly, some power of adaptation must be expected in the rearrangement under new environmental influences.

**Basic Requirements.** The defect is best replaced by an autogenous graft with sufficient living elements to be of some aid in the healing of the defect. The graft should be so applied that contact of graft

and fragments is long enough and intimate enough to use the osteogenic qualities of endosteal and periosteal surfaces of both parts. During the early months, the chief process is one of absorption and unless the graft is sufficiently strong to withstand this process until enough new bone is developed to stand the strain, there may be destruction of any freshly formed bone. In extensive defects, the graft will be relied upon to effect perfect internal fixation until union is firm enough to stand the strain of moderate motion and in the meantime, to maintain adequate bridging of the gap.

*Source of Bone.* These requirements of length, strength and osteogenesis may be best fulfilled by using cortical bone for strength and cancellous bone for osteogenesis. In loose textured bone such as ilium or rib, the process of absorption occurs rapidly so that bone of a more compact structure is necessary to splint the area adequately. To provide extensive grafts that resist stress, the best source is the medial surface of tibia or shaft of the fibula. Cancellous elements from tibia or ilium may be added for osteogenesis.

*Application of Bone Grafts.* In dealing with non-unions, there has been continued controversy over the best method of applying and fixing the bone grafts. Therefore, in the repair of extensive defects, the methods need to be even more thoroughly evaluated and assessed. Occasionally, it will be impossible in large defects to use the most perfect mechanical fixation because of the extent of the gap and shortness of the remaining host fragments.

*Medullary Grafts.* The disadvantages of this method have long been known. The fixation provided may be defective and often not entirely secure. The method minimizes the osteogenic properties of the host since it blocks the medullary canal. Apart from participation as a combined procedure, it is apparent that this technic has little place in the repair of complete defects.

*Sliding Graft.* This method has a definite place in non-unions; however, critical

analysis demonstrates disadvantages when it is applied to the bridging of gaps. It is preferable to use a graft taken from a normal bone and avoid using a sclerosed or thin atrophic fragment as a donor. These grafts also tend to be of a looser texture and become more rapidly absorbed, providing poor fixation. Where this method may be supplemented with an additional graft, it will be useful in certain defects.

*Inlay Grafts.* This method makes full use of osteogenic properties of graft and host, but in doing so, it sacrifices valuable tissue. This may be of minimal importance in a simple non-union but it is a major factor in bridging gaps. If the original attempt fails for any reason, particularly should there be reinfection, the resulting defect has been increased and the whole problem of reconstruction made much more difficult. In addition, it is a poor mechanical principle to sacrifice part of an area to which fixation is applied. The size of the graft is limited by the size of the bone into which it is inserted so that a weaker graft and less new tissue is inserted. For these reasons, except in certain cases, inlay fixation does not appear adequate.

*Diamond Inlay.* This is an excellent method since it completely removes sclerotic bone of the host and secures intimate contact. In addition, the contact that it gains is at the expense of less bone from the host than an ordinary inlay graft. However, this method has definite limitations because of the size of grafts used and the mechanics of the fixation. Since the host areas may be too rigid to allow insertion under tension, its use is limited to such areas as radius and ulna. In addition, it is a difficult graft to do properly, but in expert hands, and in proper areas, an excellent result may be obtained.

*Onlay Grafts.* The advantages of this method are that an extensive area of contact between new bone and host is provided. The grafts may be securely fixed without damaging the host bones. The width of the graft is not limited by the size of the host bones as in the inlay technic.

The method of fixation is a simple one and lends itself to many of the problems.

**Dual Onlay Grafts.** Such a technic has all the advantages of a simple onlay fixation and in addition, gives improved resistance against stress and strain. The grafts may be applied over a broad surface affording a better grip of the host bones, particularly in small atrophic fragments close to joints. A strong osteogenic element is introduced by the two large endosteal surfaces and a trough or gutter is formed in which cancellous bone may be packed or anchored in a protected position, minimizing complete absorption.

**Investigation of Fixation Methods.** These are the usual arguments advanced when dealing with the merits of the various methods. In addition to the problem of osteogenesis, the repair of extensive defects presents further special difficulties. These have to do with resistance of the graft, against stress and strain for prolonged intervals, and with the provision of perfect mechanical fixation of host and graft.

To evaluate these methods, a series of experimental grafts was done, using fresh beef bone. Defects of 2 inches were bridged by various methods. The host bones were as identical as possible in size and shape and the gap bridged was at the same point in the shaft in each case. The grafts were then subjected to direct stress. This stress was applied through a steel ring from which increasing weight was suspended. The weight was gradually increased by adding No. 2 lead shot to a container. Several containers could be added to the same suspension. Between the grafts and the weight, a scale was inserted. The host bones were fixed in metal pipes, the ends being cut to fit snugly, preventing slipping and rotation. The No. 2 lead shot was added slowly at a uniform speed. The grafts were fixed by the usual different methods available, including twisted steel wire, tied wire and Vitallium screws. All grafts were solidly fixed. When wire was used, two loops at each end maintained the graft and similarly, for screw fixation, two Vital-

lium screws were used at each end. Stress was applied slowly until the graft broke. The effects of the stress, the weaknesses and process of breaking were recorded by a slow motion camera, and carefully studied.

#### RESULTS

Type of Graft	Method of Fixation	Weight Sustained before Fracture
Inlay.....	Twisted wire	12 pounds
Inlay.....	Tied wire	42 pounds
Inlay.....	Vitallium screws	52 pounds
Diamond inlay .....	Tied wire	6 pounds
Onlay.....	Vitallium screws	90 pounds
Dual onlay. ....	Vitallium screws	196 pounds

#### ANALYSIS OF RESULTS

**Inlay Graft with Twisted Wire Fixation.** Examination of the slow motion record showed that movement appeared early at the point of wire fixation. (Figs. 1A and B.) The graft was seen to bend slightly and then the proximal end shifted beneath the wire, allowing greater range of stress application. The graft finally gave at the point of wire insertion through its substance. (Fig. 1C.) All wires were snug prior to applying stress but examination following the breakage showed that the twist in the wire gave slightly under stress, allowing movement and hence early breaking of the graft.

**Inlay Graft with Tied Wire Fixation.** No movement of the graft was demonstrable as stress was increased and breakage came through the graft itself at 42 pounds. (Fig. 2A and B.) The fixation in this case was by wire loops tied with the Harris wire tiers. This appeared as a superior method of fixation for two reasons: (1) The wires remained snug and there was no loosening at the notch to allow shifting of the graft, and (2) the graft was not weakened by a transverse slot, through its substance, which could give way at low stress.

**Inlay Fixation with Screws.** No movement of the graft was demonstrable prior

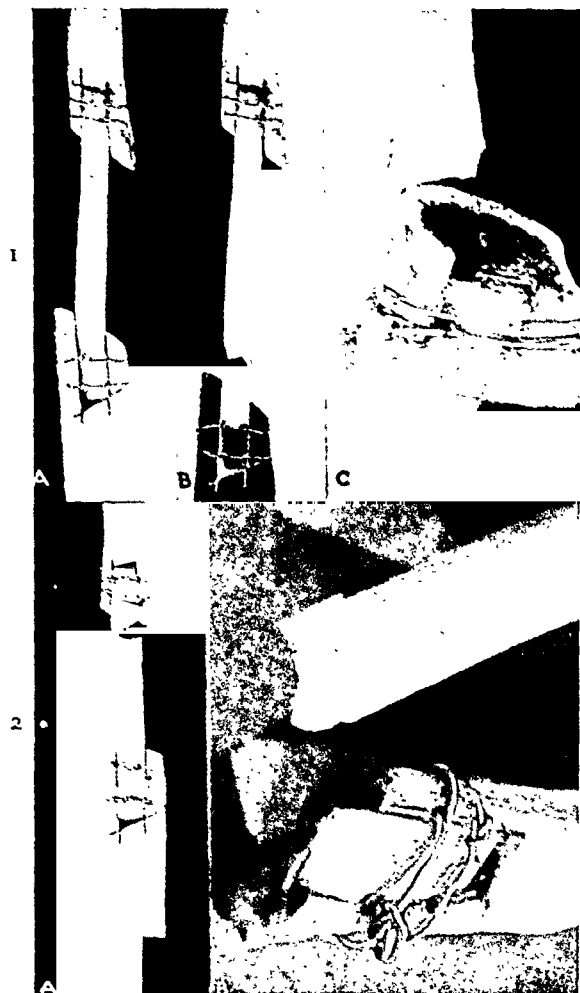


FIG. 1. A and B, inlay graft with twisted wire fixation; C, close up view of point of fracture through the tunnel in the graft.

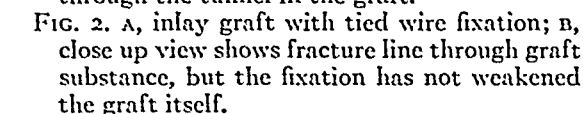


FIG. 2. A, inlay graft with tied wire fixation; B, close up view shows fracture line through graft substance, but the fixation has not weakened the graft itself.

to the breakage point. Fracture occurred through the graft at 52 pounds. Both fragments were firmly held in place and there was no slipping of the fixation. (Fig. 3.)

*Diamond Inlay.* This graft (Fig. 4) appeared solid with fixation but fracture came quickly after application of only 6 pounds. In examining the motion picture record, the graft was seen to twist very slightly and quickly break through the point of wire fixation at the proximal end. The fracture was again through the tunnel of wire fixation and at that portion where the grip of the fixation is weakest, at the distal end of a tapering graft. (Fig. 4c.) In comparing this with the previous inlay fixation that broke at 12 pounds, it is

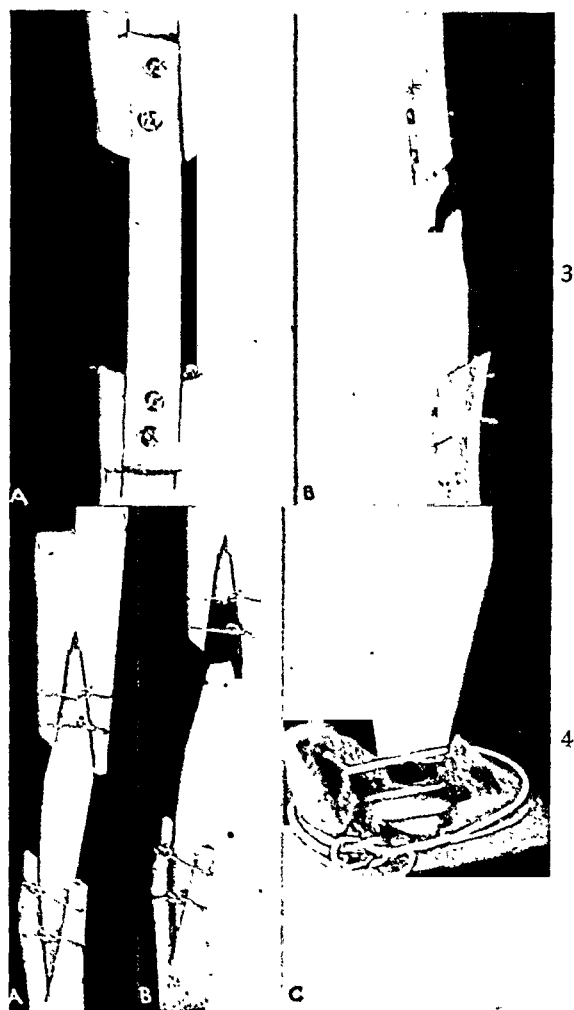


FIG. 3. A, inlay graft with screw fixation; B, shows the fracture line through the graft and not at the point of fixation.

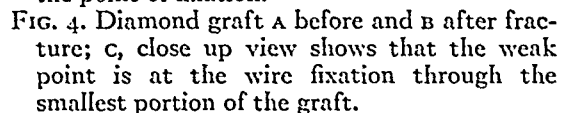


FIG. 4. Diamond graft A before and B after fracture; C, close up view shows that the weak point is at the wire fixation through the smallest portion of the graft.

apparent that the stress sustained is directly proportionate to the size of the grafts at the point of fixation, that is, about half that of the previous simple inlay fixation.

*Onlay with Screw Fixation.* The onlay graft used was the same length but just slightly wider than the previous inlay grafts. The reason for using a very slightly broader graft was that often this may be possible clinically, whereas fixation of the corresponding area by the inlay graft could be done only by a narrower piece of bone controlled by the size of the trough which may be prepared without weakening either side. This graft showed no changes until 70





**A**  
FIG. 5. A and B, onlay graft with screw fixation. The breaking point occurred through graft substance at 90 pounds.

**B**  
FIG. 6. Dual onlay graft following breakage. The fracture occurred after 200 pounds had been added, and through the graft secondarily extending to the points of fixation.

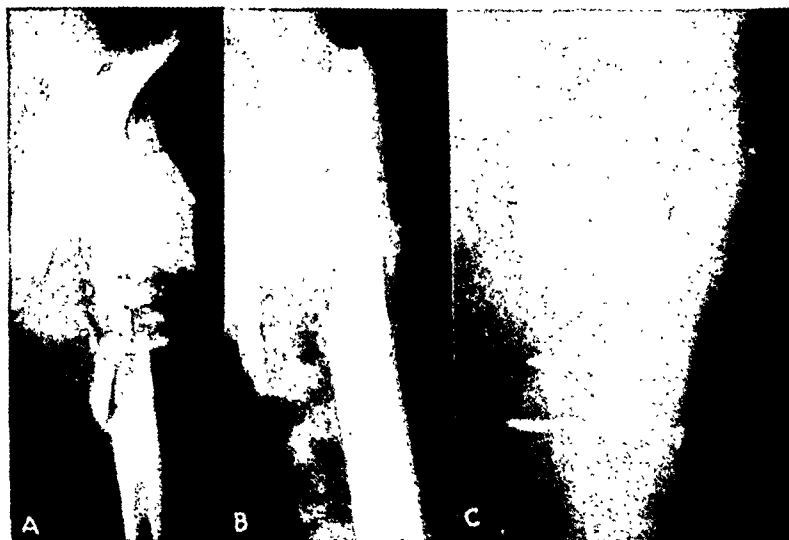


FIG. 7. Defect of upper shaft of femur. A, showing the usual shattering in a complete defect; B and C, following dual onlay reconstruction.

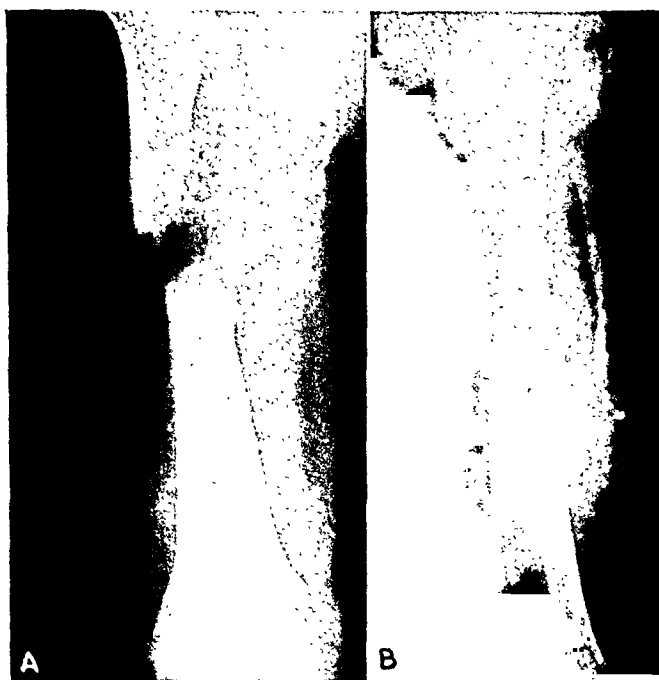


FIG. 8. Reconstruction of defect in femoral shaft.



FIG. 9.

FIG. 10.

FIGS. 9 and 10. Before and after dual grafting of complete tibial defect.

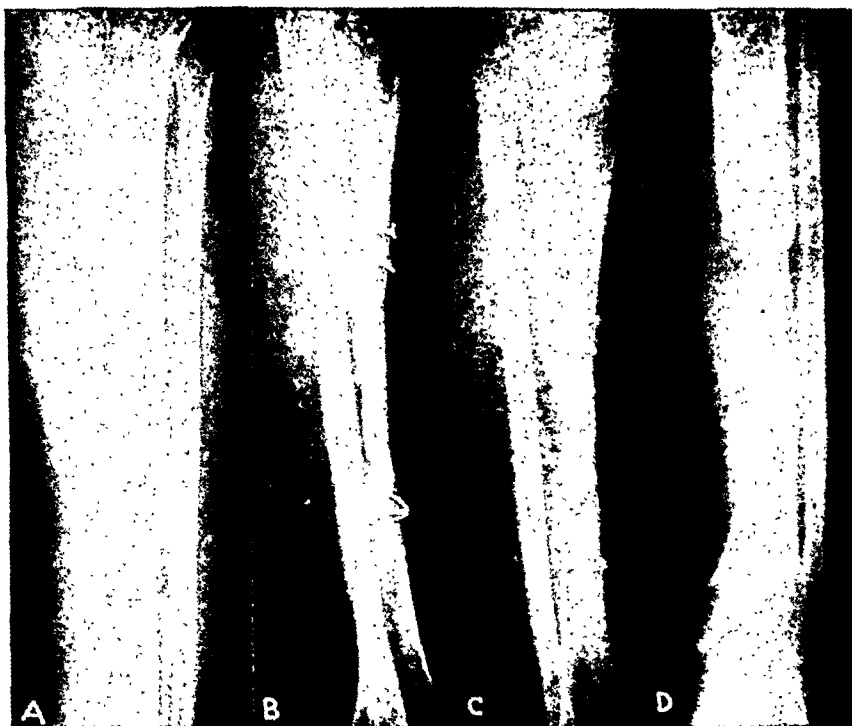


FIG. 11. A and B, reconstruction of a defect by a single tibial graft apparently solid; c and D, before removal of plaster without weight bearing this graft has fractured.

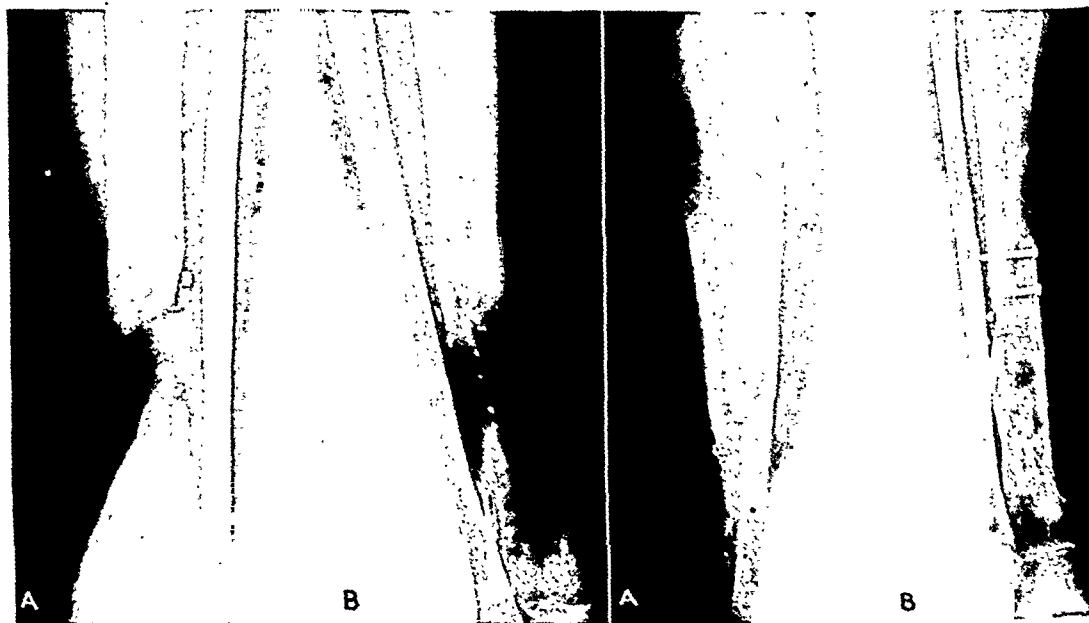


FIG. 12. Complete tibial defect complicated by amputation of opposite leg.

FIG. 13. The same as Figure 12 following reconstruction.



FIG. 14. Defect of upper shaft of radius before and after reconstruction.

pounds, at which time a slight bend was apparent. The fracture was not produced until 92 pounds had been added. The graft fragments were still firmly united to the host bones but the fracture extended to the proximal screw hole. (Fig. 5.)

*Dual Onlay Fixation.* No change was apparent in either graft after 150 pounds had been added and it was believed that fracture might not be possible within a practical range. The graft finally broke at 196 pounds. Analysis of the slow motion record showed that the superior graft broke at the distal end followed by rapid disruption of the inferior graft and proximal fixation. The primary break came through the bone with secondary disruption of the distal point of fixation. (Fig. 6.)

#### DEFECTS OF INDIVIDUAL BONES

*Femur.* Injuries involving complete defects of femoral shaft may be so severe that life is lost or more frequently, amputation follows because of vascular disturbances. Those limbs which survive often have a shattered comminuted shaft with a partial defect. This defect may be bridged by a solid cortex on one side or by frail comminuted fragments which fracture easily, and result in a pseudoarthrosis. (Fig. 7.)

Since there is but a single shaft and strong muscle pull applied to the distal fragment, defects will be shortened by the muscle pull if there are no interspaced small fragments. Those defects which remain are best bridged by a large cortical dual onlay graft fixed by Vitallium screws with abundant cancellous chips inserted. (Fig. 8.)

*Tibia and Fibula.* Similar considerations apply to large defects in the lower leg. The destruction of skin, vessel, nerve and bone may have been so extensive that amputation was a far better solution than reconstruction. This argument applied in the early stages of the case and has usually been settled before the patient arrived on this Orthopedic Service. An injury which leaves the fibula intact will produce a con-

FIG. 1.



#### USE OF "H" GRAFT.

FIG. 2.

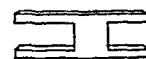


FIG. 3.



FIG. 15. Diagram of reconstruction.

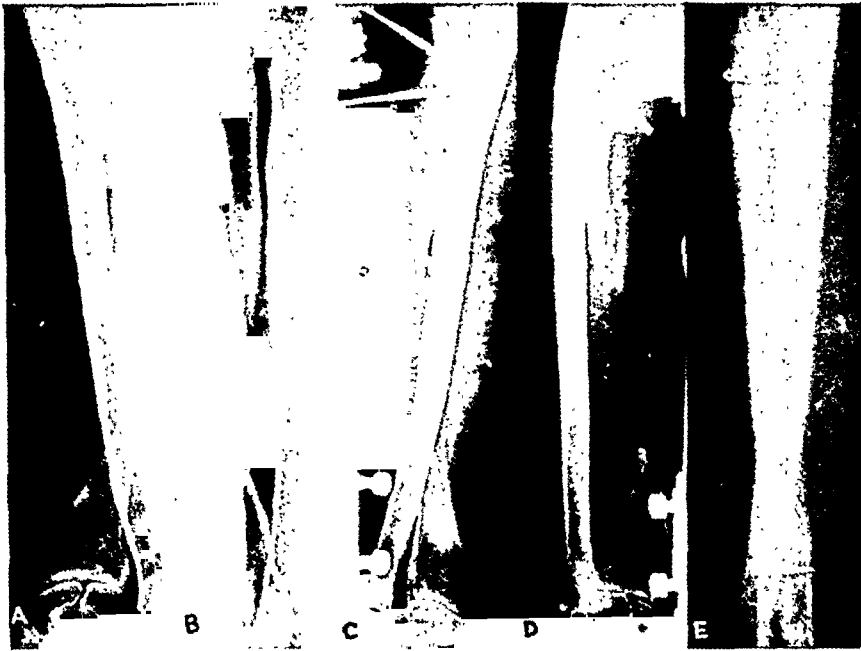


FIG. 16. Defect of mid-shaft and radius A and B before, C and D after correction of deformity; E, reconstruction by diamond graft.

siderable defect in the tibia which is maintained by the intact strut. Such defects lend themselves well to the use of dual onlay grafts and screw fixation. (Figs. 9 and 10.) Frequently, a single cortical graft will not be sufficient. (Fig. 11.) Occasionally an amputation of the other leg further complicates the reconstruction since the supply of good cortical bone is thus limited. These defects may be treated by a massive sliding graft supported by bone from the iliac crest. (Figs. 12 and 13.) A

fibular transplant, it is believed, is best reserved for a final attempt should the above procedures fail. In addition, the intact fibula while it maintains the gap, still aids materially in the immobilization of the tibial graft and fragments. Despite the size of the gaps, correction of angulation and deformity usually may easily be performed.

*Radius.* Defects of the radius produce considerable deformity, possibly more than any other long bone. The reconstruction of the radius is considered in the three regions,

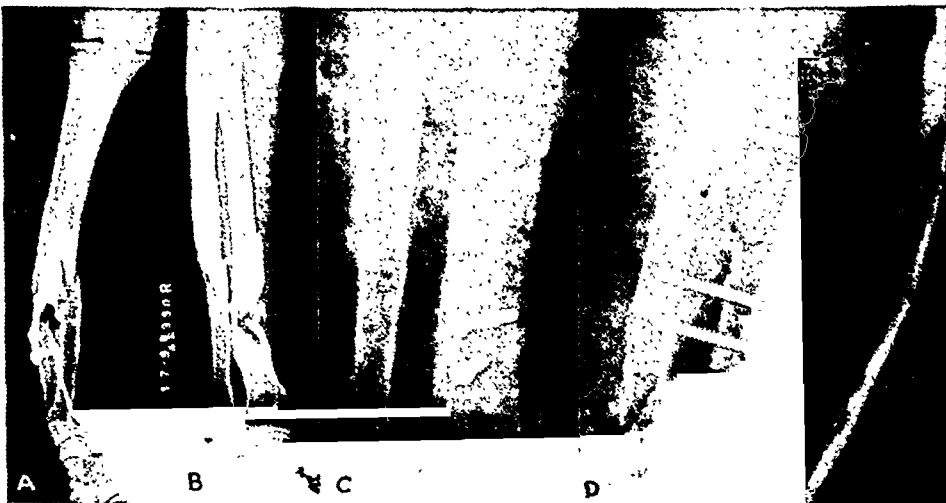


FIG. 17. Defect of lower third of radius before correction and reconstruction.

upper, middle and lower, since specific problems develop at different levels.

*Upper End.* Defects in this region may be satisfactorily corrected by a fibular graft of the "H" or reversed diamond type. (Figs. 14 and 15.) Full exposure of the shaft for fixation and control of rotation may be a little difficult. Simple, single onlay grafts are not quite suitable because of the shape of the shaft and interference with adjacent structures. The diamond method of fixation is not suitable since in splitting the small proximal segment, the crack may extend into the neck or head.

*Central Shaft.* Defects in this region may be ideally treated by a properly executed diamond inlay graft. (Figs. 16D and E.) The graft is best fashioned with a long lateral curve producing a somewhat cigar-shaped piece rather than an acutely angled diamond. Preliminary correction of the radial deviation which produces a protuberant lower end of ulna is necessary in bridging defects at this site. (Figs. 16A, B and C.) The correction may be carried out



FIG. 18. The same following correction and reconstruction with dual grafts.

by preliminary external skeletal fixation followed by a diamond graft.

*Lower End.* Significant defects of the



FIG. 19. A and B, a similar defect in radius following a diamond graft. The weak point of fixation can be seen at the lower end corresponding to the weak area found in the experimental grafts. Such a defect would have been better had the deformity been corrected first followed by dual grafting; C and D, reconstruction of central shaft by diamond graft twenty-five years ago. The shaft has been well reconstructed.



FIG. 20. A and B, large defect in ulna; c and D, following replacement with fibula.



FIG. 21. Defect of lower third of ulna replaced by dual grafts, which obtained firm grip on atrophic distal segment.

lower end also produce moderate deformity. (Figs. 17 and 18A and B.) The most difficult deformity to correct is the supination. The graft used must be able to stand moderate rotatory stress and firmly grasp the short lower end of the radius. These requisites are best fulfilled by a dual graft which will grasp the small radial fragment in pincer-like fashion, allowing correction of rotation. (Fig. 18.)

*Ulna.* Long defects are frequently encountered in the ulna and lend themselves well to replacement by the shaft of the fibula. (Fig. 20.) There is usually little deformity to be corrected and minimal rotatory strain is placed upon the graft. Fixation of grafts to the host fragments is best obtained by the onlay method, with the graft extending for at least  $1\frac{1}{2}$  inches to 2 inches in contact with the ulnar fragments. The remaining fragments of ulna are frequently small and do not lend themselves to splitting or inlay fixation. The length of overlap for onlay fixation is important in long defects of 8 inches to 10 inches to insure solid union. Defects of the lower shaft of the ulna may best be repaired with small dual grafts where the distal frag-

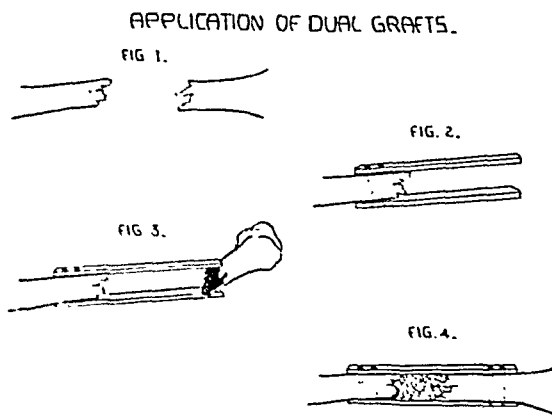


FIG. 22. Scheme of application of dual grafts. Accurate application and control of the grafts occasionally will be accomplished more easily by applying the grafts to one fragment first, levering the second into position as illustrated.

ment is small, atrophic and difficult to immobilize. (Fig. 21.)

*Humerus.* Consideration of complete defects in the upper arm corresponds somewhat to similar defects in the thigh since there is a single shaft and the strong muscle pull tends to shorten the gap. Every possible attempt must be made to save an arm despite extensive skin, vascular and nerve damage. In these days of improved plastic repair and reconstruction, amputation at any level can be considered only after every



FIG. 23. Complete defect of mid-shaft and humerus before and after reconstruction.



possibility of conservative therapy has been thoroughly considered. In the humerus, deformity is easily corrected in the midshaft area but less easily in the lower third. Most complete defects of the humerus are best treated by dual onlay fixation, (Figs. 22 and 23), this applies particularly to defects of the lower third in which the short distal fragment may be held in a pincer-like grip by two grafts.

#### SUMMARY

The general principles in dealing with extensive and complete bone defects have been outlined. These include careful management of infection, preliminary skin repair and early treatment of damaged associated structures. An experimental investigation of the effects of one form of

stress on the various methods of graft insertion and fixation has been outlined. The results indicate the superiority of single and dual massive onlay grafts and screw fixation. These principles have been applied and illustrated in a discussion of the best forms of bone replacement in the different long bones.

The author wishes to thank Dr. R. I. Harris, Dr. G. M. Dale and Dr. H. M. Coleman of the Orthopedic Service for their kind permission to use Figures 8, 10 and 16.

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# USE AND ABUSE OF INTESTINAL DECOMPRESSION TUBE

## A STUDY BASED UPON TWO HUNDRED CASES\*

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IN the past ten years, with the introduction of the long intestinal decompression tube, and newer methods facilitating its passage through the pylorus and so well down into the gastrointestinal tract, lives have been saved that might otherwise have been lost. Many articles<sup>1,2,3,4</sup> have appeared extolling the virtues of the tube in the treatment of intestinal distention. Then its use in the non-operative treatment of certain types of intestinal obstruction began to appear.<sup>5,6,7,8</sup> A glance through the Quarterly Cumulative Index Medicus for this past decade reveals many articles discussing this new method of treating certain types of intestinal obstruction by intubation alone. The trend has gone so far, that in many hospitals, patients admitted with a diagnosis of possible bowel obstruction have a long intestinal decompression tube passed, usually by the intern and then a period of waiting is begun. Some men expect the intestinal decompression tube unaided to relieve the patient of his distention and so obviate the necessity for surgical intervention.

Many men fail to realize that the intestinal decompression tube is merely an instrument like a hemostat and will help the patient only so far as the knowledge of the surgeon in the use of the tube. Even in the passage of the long intestinal decompression tube, many surgeons are completely uninformed or consider it the task of the intern to pass these tubes and to

supervise the downward progress. We have seen the operator neglect to tie off the neck of the sac containing the mercury, (Fig. 15) and then pass three feet of long tube into the stomach and put the patient through various acrobatics in an effort to get it to pass. The only result of this type of activity is failure because of coiling in the stomach or knot formation and a leakage of the mercury through the lowest hole.

### CASE REPORTS

CASE 1. L. C., a thirty-year old white man, was admitted to Grace Hospital on July 13, 1946, with a diagnosis of acute bowel obstruction. On admission he appeared acutely ill. He had been vomiting for two days and had passed no gas per rectum for the same period. His abdomen was greatly distended and tender. He had been operated upon twice previously, once for appendicitis and once for bowel obstruction. At this last operation an anastomosis was performed between the ileum and the transverse colon. A Cantor tube was passed upon admission. Check films taken twenty-four hours later revealed the tube in the distal jejunum. The distention gradually decreased and his abdomen became soft. On the fourth day, he passed gas per rectum. On the fifth day, he was taken to the operating room and the abdomen opened. The tube was found to have passed through the jejunum and its tip came to rest at the site of the previously performed ileo-transverse colostomy. At this point, the small bowel was found to be obstructed by loops of ileum passing around the anastomosis. The anastomosis was taken down and the continuity of the transverse colon was re-established by

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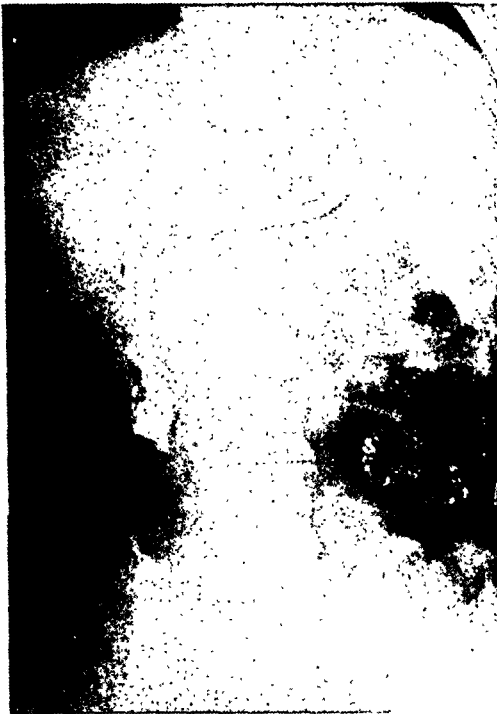


FIG. 1. Note the intestinal distention. Much of the mercury had leaked out of the balloon and is disseminated along the gastrointestinal tract. Note also that the "head" of the tube is in the duodenum.

an end-to-end anastomosis. The ileum was resected and an end-to-end anastomosis done. The Cantor tube was removed accidentally by the anesthetist so a Witzel enterostomy was performed six inches proximal to the end-to-end anastomosis in the small bowel. The patient became distended postoperatively and began to vomit. The tube was reinserted. The resident who passed this tube neglected to tie off the end of the balloon. As a result the mercury ran out of the bag. A twenty-four hour check film showed that the tube head was in the duodenum but almost all the mercury had run out of the bag and was found throughout the gastrointestinal tract. (Fig. 1.) A forty-eight hour film showed that the tube had advanced to the duodenojejunal flexure and that a loop of tube had moved along with the tip. (Fig. 2.)

It is interesting to note that even though there was very little mercury in the balloon, yet the tube had passed through the pylorus into the duodenum. The decompression obtained, however, was good. For the next two weeks globules of mercury were found on the dressing of the enterostomy. The patient left the hospital greatly improved.



FIG. 2. Distention has decreased considerably. In spite of the fact that very little mercury remains in the tube "head," the tube has moved further along the gastrointestinal tract. A loop of tube has moved along faster than the tube "head" and is found along side of it. Note the decrease in amount of mercury in the gastrointestinal tract.

CASE II. H. G., a thirty-two year old white woman, was admitted to Grace Hospital on August 3, 1946, with a diagnosis of acute pelvic peritonitis and paralytic ileus. A Cantor tube was passed by the resident who forgot to tie off the bag. As a result most of the mercury leaked out and was found in the small bowel. In spite of this the tube was found to have passed through the pylorus and at the twenty-four hour check film it was found in the second portion of the duodenum. (Fig. 3.) The next day the tube had passed into the jejunum. The abdominal distention rapidly decreased, (Fig. 3B) so that by the third day the abdomen was quite flat. On the seventh hospital day the patient began passing flatus per rectum. On the tenth hospital day, the tube was removed. The patient had a bowel movement on the eighth and tenth days. Globules of mercury could readily be seen in the stool. The patient made an uneventful recovery. A left salpingo-oophorectomy was done on the fourteenth hospital day.



FIG. 3. A, the mercury has almost completely leaked out of the tube "head" and yet the tube passed through the pylorus into the duodenum. There is a spread of mercury throughout the gastrointestinal tract. Compare this film with Figure 3B and note the marked decrease in distention. B, flat plate of patient shown in Figure 3A. Note the marked intestinal distention.

These two cases exemplify the fact that even under the worst possible conditions of handling the tube will usually pass through the pylorus. They also demonstrate rather well that mercury is not absorbed and is completely innocuous being excreted by the patient with every bowel movement.

We would like to emphasize that the intestinal decompression tube is a tube that will, if properly used, decompress the gastrointestinal tract of the patient, and nothing more. With this fundamental principle in mind, that the only function of this tube is intestinal decompression, we can now consider just how its use is of value and under what circumstances a definite danger to the patient

From a surgical point of view, the first use for this type of tube would be in the severe types of postoperative distention and ileus. The milder types of distention postoperatively have been shown to be due to ingested air,<sup>9</sup> and can easily be re-

lieved by withholding food for several days or by the use of a Levin tube and suction. However, the severe forms of postoperative intestinal distention and those cases of ileus which are due to intra-abdominal infection definitely require the long intestinal tube. In this type of case, the use of the tube can be a life saving measure, providing the surgeon is certain that the patient is not suffering from postoperative intestinal obstruction instead of ileus. Here, the brain of the surgeon and not the tube may save or lose the patient. Sometimes the differentiation is difficult to make, but if effective intestinal decompression is carried out and the abdomen becomes flat but a knuckle of bowel is obstructed by adhesive bands or by passing through a rent in the broad ligament or omentum, obviously such a decompressed bowel merely lulls the surgeon into a false sense of security while the obstruction goes on and inevitably produces strangulation and perforation of the bowel. The use of the tube in post-



FIG. 4. Marked distention of the intestinal tract.

operative ileus due to pelvic peritonitis or general peritonitis, or in cases of ileus due to a small pocket of pus in the pelvis following surgery constitutes the type of case in which the results of intestinal intubation are most brilliant, but the use of the long tube therapeutically in intestinal obstruction is exceedingly dangerous.

CASE III. C. B., a thirty-seven year old white woman was admitted to Grace Hospital on July 11, 1946, with a diagnosis of intestinal obstruction. On examination, her abdomen was found to be markedly distended. She had been vomiting for one week, and had passed no gas per rectum. A flat plate taken on July 13, 1946, (Fig. 4) revealed a dilated jejunum and ileum indicating intestinal obstruction probably at the level of the ileum. A Cantor tube was passed. Check films taken twenty-four hours later revealed the tip of the tube to be well past the ligament of Treitz in the upper segments of the jejunum. The intestinal inflation had markedly decreased. A forty-eight hour film showed the tube to be in the ileum. (Fig. 5.) There was considerably less inflation in the small bowel than previously noted forty-eight hours ago. The patient was taken to the operating room July 15, 1946. At operation multiple adhesions of the small intestines and ascending



FIG. 5. Marked decrease in intestinal distention. The tube "head" is well down the intestinal tract. The tube is visualized so well that even the holes in the tube stand out.

colon were found. These were the result of a right salpingectomy which had been done six months previously for ectopic pregnancy. The adhesions producing the obstruction were separated. A sterile abscess was then encountered on the right side between the ascending colon, abdominal wall and small intestines. Much granulation tissue was found on the intestines. The bowel had been completely obstructed by adhesive bands. Recovery post-operatively was uneventful. The patient was discharged on the eleventh postoperative day.

Here we have a case in which two separate and distinct etiological factors were found. Either one of these (abscess or adhesions) could have produced the abdominal distention. If a diagnosis of ileus due to abscess were made, and the patient treated by intubation alone, it should be quite evident that the results would be disastrous.

If the tube is to be used in cases of bowel obstruction, we believe that its only function is to decompress the gastrointestinal tract and so give the surgeon time to study the patient and properly prepare him for



FIG. 6. Marked distention on flat plate of the abdomen.



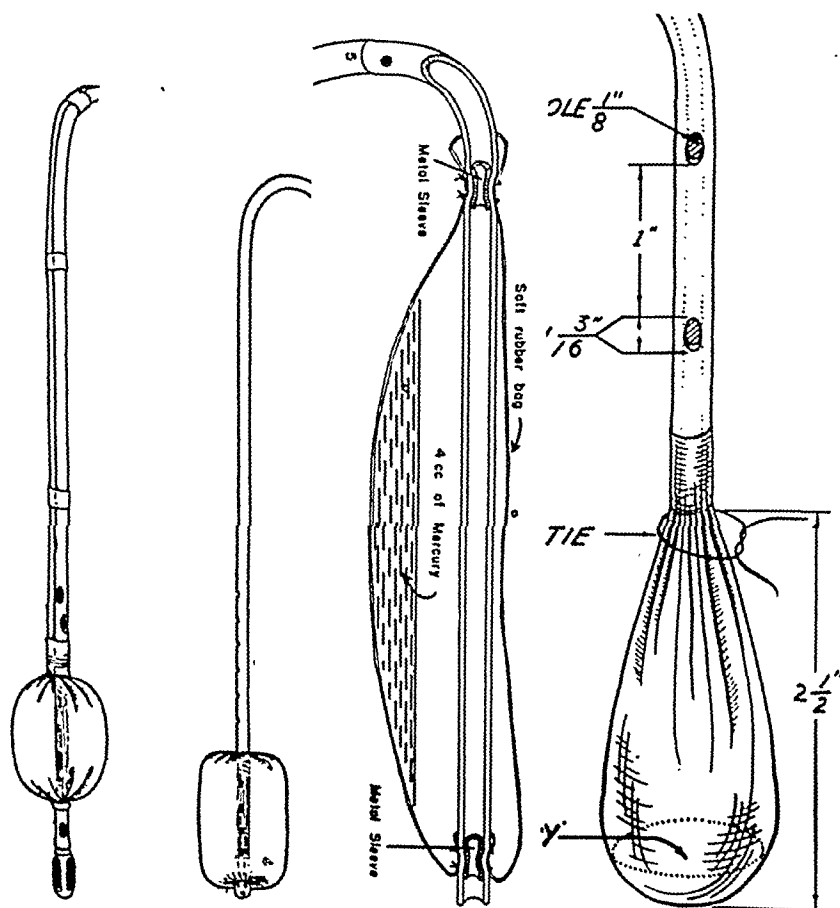
FIG. 7. Tube down in the intestinal tract. A small amount of barium made it possible to visualize the marked distention well. Note the size of holes in tube which made aspiration simple.

surgery. We cannot subscribe to the idea that many types of non-strangulating intestinal obstruction, non-inflammatory in nature, can be cured by intestinal intubation alone. Although it is true, that if the obstruction is due to an inflammatory exudate, the use of the tube will keep the bowel decompressed until the exudate or inflammatory area producing the obstruction is resolved with a resultant release of the obstruction. This type of case we classify with the inflammatory distention group. Cases of mechanical intestinal obstruction whether due to adhesive bands, internal hernia, torsion of bowel, foreign body in the bowel, tumors of bowel, or in fact any non-inflammatory obstructive lesion should be operated upon. The preliminary use of the long tube for decompression is merely an aid to proper surgical intervention and must not replace surgery.

The long tube can be used very successfully to keep the bowel decompressed preparatory to bowel resection for a known lesion. In this type of case, an end-to-end anastomosis can be done safely with the

tube *in situ* above the point of anastomosis, or the tube can be used as a safety valve in many cases in which a Witzel enterostomy would be done. The function of the intestinal decompression tube here would be much like the safety valve enterostomies that are often done to prevent undue strain on the line of anastomosis. In the following case, this technic was used with excellent results:

CASE IV C. J., a fifty-one year old white man, was admitted to Grace Hospital on August 8, 1946, with a diagnosis of intestinal obstruction. On examination, he was found to be markedly distended and his abdomen was tender. He had vomited for two days. A Cantor tube was passed. Twenty-four hour roentgen examination showed the tube to be in the jejunum. (Figs. 6 and 7.) The abdominal distention decreased markedly with suction applied to the tube. At operation ten days later, an annular carcinoma of the rectosigmoid producing intestinal obstruction was found. A colostomy was done as a first stage for resection. Convalescence was uneventful and the



Johnston      Miller-Abbott      Harris      Cantor

FIG. 8. The "head" of each of the four intestinal decompression tubes in use today. This head constitutes the propulsive mechanism. In only one head is there a radical departure from previous types. Note the complete absence of all metal parts in this tube head.

patient was sent home to return at a later date for resection.

In this case, the long tube carried the patient over the emergency and enabled the surgeon to prepare the patient carefully so that the subsequent surgery could be done with a minimum of effort to the surgeon and risk to the patient.

In the foregoing discussion, it has been assumed that the long tube has been properly passed and that it has moved down into the small bowel. Unfortunately, that is not always the case. The proper passage of the long tube requires a great deal of patience and "know-how." It cannot be relegated to the junior intern or to the

nurse on the floor. The experience of our x-ray department has been that too often the tube has been passed by someone without the faintest idea of the mechanics involved. The result is failure regardless of the type of tube used. The most common error that we found in passing these tubes is the passage of too much tubing into the stomach without regard to the problems involved in passing the specific tube in question. The surgeon should be familiar with the principle involved in the construction of each type of intestinal decompression tube and the method of passage advocated by the proponents of that tube. Figure 8 shows the different heads on the various intestinal decompression tubes in

use today. The surgeon who developed each tube designed the head of the tube to satisfy certain criteria that he thought necessary in order to get the tube to pass.

A glance at Figure 8 will readily reveal that the Miller-Abbott and Johnston tubes are double lumen tubes with the balloon attached along the shaft of the distal end of the tube, and with a small segment of tube, usually covered by a metal perforated knob, at the very end of the tube. Both these tubes were designed to meet the idea of Miller-Abbott and Johnston that, "it is necessary to decompress the gut in front of the balloon in order for the balloon to then act like a bolus when inflated. In this way the tube is carried down the gastrointestinal tract." The only other difference between the tubes is the fact that in the Miller-Abbott tube the double lumen is inclosed in one sheath whereas in the Johnston tube the luminal diameter for suction is greater and the tubes are externally attached to each other. Here, then, we have the principle of decompression in front of the balloon and hence the construction of a tube with the power of decompressing in front of the tube. When Harris<sup>10</sup> suggested placing mercury in the balloon of the Miller-Abbott tube in order to facilitate its passage, the design of the original tube remained the same. The result is that the tube is used as a combination mercury and air tube, acting we believe like a "shot-gun" prescription for it embodies the use of two completely different propulsive principles. Harris for several years<sup>11</sup> had also been developing a single lumen mercury weighted intestinal decompression tube in which the mercury alone was placed in the balloon as the sole propulsive agent. However, a glance at Figure 8 shows readily that the placing of the balloon along the shaft of the tube at its distal end was exactly like that of the Miller-Abbott tube with the tip open for suction. Since it should be quite evident that only the distal end of the tube or its "head" constitutes the propulsive mechanism, then the same problems would arise

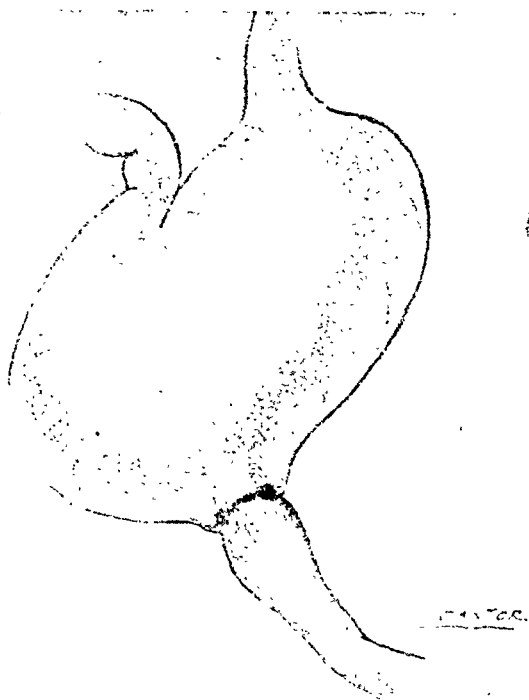


FIG. 9. This patient had had a partial gastrectomy some time previously. Note the stoma position. Turning this patient on his left side would make passage of mercury weighted tube impossible as it would pass into proximal loop.

in the passage of the Harris tube as in the mercury weighted Miller-Abbott tube. We do not believe that placing the shaft through the balloon permits the free flow of mercury, and tends to make the "head" so bulky that difficulty often arises in passing it through the nose. The Cantor tube was designed to permit the utilization of all the physical properties of mercury to the utmost. For this reason, a loose balloon was placed at the very end of the tube. This is to permit a "free-flow" of mercury in a very loose bag. Because of this "free-flow" and the weight of the mercury the surgeon must maneuver the patient in order to take advantage of this tube design. The complete absence of all metal in the tube and the terminal attachment of the balloon makes it possible to pass this type of tube painlessly even through the narrowest of nasal passages without much discomfort. Figure 9 is a drawing of the type of case in which it was found to be impossible to pass any other type of tube. In order to pass the Cantor





FIG. 10. Tremendous amount of distention (portable film).

tube here, it was found to be necessary to increase the amount of mercury to 8 cc. and to stand the patient up in order to get the effect of a dilating wedge against the stoma. It is the same mechanism as that seen by the bag of waters in dilating the cervix during labor.

Although we are making an effort to standardize the technic of passing the long mercury weighted intestinal decompression tube in order to facilitate its passage through the pylorus and so into the small intestine, it must be borne in mind that each case is somewhat different and slight variations in technic are necessary in order to insure success.

The illness of the patient is an important consideration. A critically ill, dehydrated, weak patient must be treated much differently from a robust man who is chronically obstructed. It may not be possible for the patient to co-operate in the passage of the tube, or the intestinal tone of the patient may be so poor that the peristaltic activity of the bowel as an aide to the passage of the tube is entirely absent. Here we would necessarily have to rely upon the physical properties of the mercury to secure passage

of the tube. That is, the effect of gravity and motion upon a loose balloon-tipped tube weighted with freely movable mercury. The physical properties of mercury, i.e., its weight and lability and the effect of gravity would have to be used to the utmost. For this reason, changes in position of the patient (early ambulation and motion) are most important.

CASE V. I. A., a seventy year old white man, was admitted to Grace Hospital with a diagnosis of ileus. On examination, his abdomen was found to be markedly distended. There was marked tenderness over the descending colon. Temperature, pulse and respiration were normal. White blood count and differential were also normal. Sigmoidoscopic examination revealed no pathological condition. Because of the marked distention a Cantor tube was passed. A twenty-four hour survey revealed the tube to be down into the distal jejunum. The abdomen was considerably softer and flatter. Two days later a small amount of barium was injected through the tube into the small bowel. (Figs. 10, 11, 12.) Series studies were made which showed a cherry-sized diverticulum in the proximal jejunal loop in the midportion of the left abdominal cavity. The barium was seen to pass into the proximal portion of the transverse colon. No obstructive process was demonstrated. Fluoroscopic examination of the large bowel during and following the administration of a barium enema revealed normal colonic size, position and configuration. Roentgenograms obtained before and after evacuation showed no evidence of disease in the large bowel. His abdomen gradually became soft and flat. He passed a soft stool on the fourth and fifth days. The tube was removed. He was up in a chair. Three days later he suddenly complained of pain in the chest radiating down the arms. He presented all the clinical findings of severe coronary occlusion and died.

Here we find a case of severe adynamic ileus in which the intestinal distention was properly treated by the use of a Cantor tube. Leaving the tube *in situ*, it was possible to carry out x-ray studies of the bowel without danger. At the first indication of obstruction, it would have been possible to aspirate the excess barium through the



FIG. 11. Tube well down the gastrointestinal tract. A small amount of very liquid barium has been injected. Note decrease in amount of distention.



FIG. 12. Note the absence of all barium from the small bowel, and its presence in cecum and ascending colon. There is a great decrease in intestinal distention.

tube. The use of the tube here makes possible roentgen studies in this type of ileus which might otherwise have been very dangerous.

It must be realized that in any of the channels through which the tube must pass to get into the jejunum, that there may be barriers to its passage. These can usually be overcome by a judicious mixture of common sense, a knowledge of anatomy and various drugs that we have in our armamentarium. The nose, the cardiac sphincter of the stomach, the pyloric sphincter, the ascending limb of the duodenum, the posterior position of the pouch of the fundus of the stomach, all these require some maneuver to prevent trapping any mercury weighted tube. Remember always, that a free flow of mercury and gravity carries the tube downward and that peristaltic activity may or may not aid. A mercury weighted tube will run uphill, if at all, with great difficulty. Put the patient in such a position, that the mercury weighted head will always run

downhill to get to the area into which we want it to go.

The height of the patient is of importance in the passage of the tube. A tall patient with a long thorax will obviously require a greater initial length of tube to reach the pylorus than would a short, fat patient with a high diaphragm. If the same length of tube were used in both cases, the tube that would reach the pylorus of the tall patient would coil up in the stomach of the short one. For a patient of average height, if twenty-four inches of tube is passed first, the balloon should be at the pylorus with enough slack to permit it to pass through. In a short patient less tube should be used.

Before attempting to pass the long intestinal decompression tube, the patient must be given a hypodermic injection of morphine sulfate gr.  $\frac{1}{6}$  and atropine sulfate gr.  $\frac{1}{150}$ . This will allay nervousness in these sick people and tend to relax the cardiac and pyloric sphincters. If this is not done, the extreme nervousness of some



FIG. 13. Tube "head" weighted with mercury comes to lie in fundus of stomach with patient flat on back.



FIG. 14. The "head" of tube trapped in the lower esophagus while a long loop has worked its way well into the stomach.

patients will result in a cardiospasm or pylorospasm effectively blocking the entrance into and the outlet of the stomach so that no tube could pass. Figure 14 exemplifies this type of case. Here we see, the balloon containing the mercury trapped in the lower esophagus while a loop of tube slipped by and passed into the stomach. When this patient was given morphine sulfate gr.  $\frac{1}{4}$  and atropine sulfate gr.  $\frac{1}{100}$ , the mercury weighted balloon dropped into the stomach and from there downward into the jejunum. The value of the two-hour x-ray to demonstrate the position of the tube is well shown here. Although the stomach was being effectively decompressed, the tube would never have passed downward into the jejunum until the mercury weighted balloon had passed from the esophagus into the stomach.

On several occasions we were consulted by the intern because he found it impossible to get any long tube through the external nares of the patient. The question always arose whether to pass the tube through the mouth. In all the cases that

we saw, it was emphasized that a preliminary examination of the external nares is imperative. All these cases presented some nasal pathological condition. In two cases, the turbinates were tremendously enlarged by chronic sinusitis. The application of a 2 per cent ephedrine solution to the nasal mucosa effectively shrunk the turbinates and permitted the passage of the soft compressible head of the Cantor tube with ease. In one case, the septum was markedly deviated to the right. All that was required here was to pass the tube through the left side. One case presented nasal polypi. Here a solution of ephedrine and pontocaine resulted in an easily passed tube.

Elevating the foot of the bed twelve inches and turning the patient on his right side will usually cause the mercury in the balloon tipped tube to run down to the apex of the stomach (pylorus) and so drag the tube after it. If the patient lies on his back, it must be remembered the fundus of the stomach lies in a pouch in the left paravertebral gutter posterior to the antral portion of the stomach. The weight of the

mercury in the balloon head would keep the tube head in the fundus as long as the patient lay in this position. Figure 13 demonstrates well that the heavily weighted head of the tube does not drop to the antrum when the patient lies flat on his back, but always lies in the fundus because of its posterior position. Just how long the patient must lie on his right side and inclined toward his face in order for the balloon-tipped tube to pass through the pylorus varies with the amount of mercury in the balloon, the presence or absence of peristaltic waves in the stomach, the tonus of the stomach and finally the ability of the patient to tolerate the position. Generally an increase in the amount of mercury in the tube head results in an increase in the speed of its passage through the pylorus. This is particularly true in cases in which the tonus of the stomach is poor or in robust people in whom we wish to have the weight of the mercury exert a greater push. In the vast majority of cases, at the end of two hours the tube will have passed into the duodenum. For this reason, we permit these people to lie in this position for two hours.

At the end of the first two hours, we lower the foot of the bed and put the patient up on a backrest in order to take advantage of the effect of gravity on the weighted head in inducing its passage downward along the descending limb of the duodenum. We pass four inches more of tube every two hours. We do not push the tube down, but rely upon the constrictors of the pharynx to carry it down while the patient drinks water. In this way, kinking of the tube is avoided. If the tube is held in the palm of the hand loosely and the patient drinks water, the tube will be seen to pass downward with each swallow.

The third and last maneuver is to leave the patient upon the high backrest and turn him on his left side to secure passage through the third portion of the duodenum across the abdomen. From this point on, moving the patient about and changes of position usually cause the tube to pass well

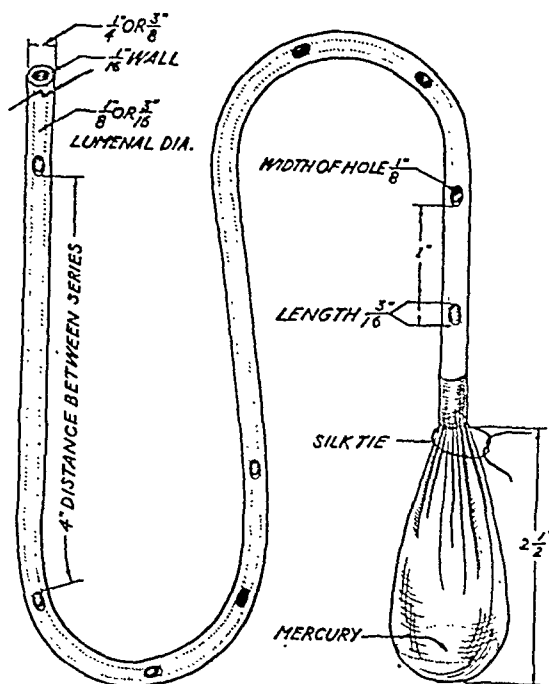


FIG. 15. The tube is all rubber and the head is very thin, highly pliable rubber. There are no metal parts whatever so that tube is compressible enough to pass easily through the narrowest channels. The tube must be tied off at the neck of sac before using in order to prevent leakage of mercury. Note the larger caliber of lumen of tube and of holes for decompression.

down the gastrointestinal tract. In only eight cases were we unable to pass the tube into the jejunum. At no time do we push the tube down into the patient, but rather do we rely upon the swallowing of the patient and the effect of motion and gravity to pass the tube. For this reason, the tube must not be fastened to the face of the patient. Permitting it to lie free, insures its passage downward unaided when peristaltic activity is re-established.

The surgeon should not depend blindly upon the suction device to decompress the patient adequately. Frequent and repeated checks should be made to be sure that the suction is properly connected and functioning. This is particularly true if the Wangenstein bottle method of suction is used. This should not be the function of the nurse. No matter how far the tube progresses into the patient, poor suction spells poor results.

Correction of the distention is only one phase of the treatment. Restoration of the

fluid balance and electrolytes as well as vitamin requirements is of the greatest importance if a favorable outcome is to be expected.

#### SUMMARY

By using a single lumen long intestinal decompression tube<sup>12</sup> with a mercury weighted balloon tipped head, (Fig. 15), we have been able to intubate successfully 96 per cent of two hundred cases of intestinal distention. The eight failures we believe to be due to a failure to appreciate certain fundamental principles as noted in this paper. The surgeon alone must be responsible for the passage and progress of any intestinal decompression tube if it is to serve the function adequately for which it was designed. It is just as important to pass the long tube properly and adequately decompress the distended abdomen as it is to open that abdomen.

It must be realized that the intestinal decompression tube is merely an instrument and must be used as such by the surgeon and not be relegated to the intern or nurse.

Intestinal decompression tubes should be used only as an adjunct to surgery in cases of bowel obstruction and must not replace surgery. We classify our cases of intestinal obstruction into four groups for purposes of intestinal intubation. These groups are:

Group 1. All cases of ileus due to atony of the bowel, or adynamic and dynamic. All cases in which the obstruction is not in any way mechanical. In this group we use intubation alone.

Group 2. All cases of ileus due to inflammatory lesions. In this group would fall all cases of ileus due to general peritonitis, local peritonitis, plastic exudate, inflammatory masses and any inflammatory process capable of causing ileus. In this group intubation alone may be used until all evidence of acute inflammatory reaction has subsided. Most of these patients do not require surgery, although some will be complicated by

adhesive bands and must be operated upon before they are well.

Group 3. All cases of ileus due to mechanical lesions. These vary from mesenteric thrombosis to carcinoma of the rectosigmoid. All these must be operated upon. Intubation aids in making the working field much easier by collapsing the small bowel. Intubation also gives the surgeon time to prepare the patient properly for surgery and so improves the risk to the patient.

Group 4. Patients subjected to selective operations or who would ordinarily have an enterostomy preparatory to anastomosis of bowel or resection. Intestinal intubation obviates the necessity for enterostomy in this type of case.

Intestinal intubation should be entrusted only to one who understands the mechanism involved in the passage of the tube and who is willing to spend the time with the patient to insure proper passage. A long intestinal tube in the hands of the novice is indeed a most dangerous instrument.

#### CONCLUSIONS

1. The "head" of the long intestinal decompression tube constitutes the propulsive mechanism.

2. A balloon tipped mercury weighted single lumen tube is by far the most efficient instrument to produce intestinal compression.

3. The only cases in which intestinal intubation alone can be safely used are cases of adynamic ileus or cases in the inflammatory distention group.

4. The use of the long intestinal decompression tube as a preliminary to bowel resection or anastomosis obviates the necessity for enterostomy and hence reduces the risk to the patient.

5. The long intestinal decompression tube in the hands of a novice is a very dangerous instrument.

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I should like to express my appreciation to the Clay-Adams Company of New York for manufacturing these tubes and for furnishing them to me gratis for this study.



# WOUNDS OF THE COLON AND RECTUM

LIEUT. COL. J. EDWARD FLYNN

MEDICAL CORPS, ARMY OF THE UNITED STATES

WOUNDS of the large intestine and rectum are most serious as far as war wounds are concerned. Mortality with wounds of the large intestine and rectum will be relatively low in our soldiers, mainly because of our means for controlling shock and infection, the good nutrition of our soldiers and the fact that early surgery is performed.

Wounds of the colon constituted 22 per cent of all intra-abdominal visceral injuries in the American Forces in World War I. It is often the only part of the alimentary tract injured. Wounds of the rectum were relatively infrequent. They constituted only 2.4 per cent of the lesions of the abdominal viscera in World War I. Lesions often associated with rectal wounds are those of the bladder, the pelvic colon and less frequently, injuries of the small bowel.

Uncomplicated perforations of the large intestine which are caused by a single small missile, when associated with only slight spillage of semisolid fecal material, are attended by a relatively low mortality if early closure of the perforation is performed. Large perforations are usually followed by rapidly developing sepsis, and many of the patients with such injuries die within a few hours. In World War I, the mortality record for wounds of the large intestine was 58.7 per cent, compared with a mortality of 65.6 per cent following wounds of the small intestine. However, the British quote statistics with a higher mortality for colon injuries, than for small bowel injuries. In World War I, the death rate following colonic injuries was greatly increased by the group of cases in which colostomy was performed, the mortality after suture of the colon being only slightly more than 50 per cent, while that following colostomy was 75.5 per cent. This does not

mean that colostomy is necessarily a dangerous operation but that the sepsis is likely to cause death in cases in which colostomy is required.

The mortality following wounds of the rectum in World War I, was 45.19 per cent. Death was usually due to rapidly advancing sepsis in the retroperitoneal tissues, or to spreading peritonitis.

## WOUNDS OF COLON AND SMALL BOWEL

Wounds of the large intestine may resemble those of the small bowel. (Fig. 1.) A single punctate wound is rarely found in the large and small bowels. Simple transverse wounds are rare but are more often found than punctate wounds. Closely situated punctate wounds of the colon may be exteriorized or may be made to communicate, closed as a single wound and a proximal colostomy made. Multiple wounds may be closed individually. A wound which almost transects the colon may be exteriorized, or treated by suturing or resection and a proximal colostomy made. Multiple lacerated and punctate wounds require resection when separate closure of the perforations is not feasible. The serosa and muscularis may be stripped back from the mucosa as the mesentery is torn away. With a rupture of the muscular coat, ulceration of the mucous membrane may occur. This latter complication may occur within a few hours after wounding. With the rupture of the muscular coat, the blood supply to the mucous membrane is cut off. This may be due to the sudden impact of a projectile on a sac filled with gas or a projectile may exert a dragging effect through strands of fibrous tissue. These ulcerations of the mucosa are likely to be due to air and water blast and probably account for some of the fistulas which form in cases in which the colon was

thought to have escaped injury. A hematoma of the mesentery may hide a perforation of the bowel. Wounds of the mesentery may be accompanied by thrombosis of the mesenteric blood vessels and infarction of the bowel.

*Types of Injury to Colon.* Wounds of the large intestine may differ from wounds of the small intestine. Because of the lack of numerous coils, perforating wounds of the colon are less often multiple than those of the small bowel. Multiple lesions when found, usually involve the redundant pelvic colon or the flexures. Some small perforations may be caused by minute spicules of pelvic bone and are much more difficult to recognize than are the injuries caused directly by missiles. The large size of the colon leads to a preponderance of tears or perforations. Some of the wounds are large and ragged. Complete division of the bowel may occur, but it is less frequent in the large than in the small intestine. Complete division occurs when the bowel is collapsed, in which state it may be only slightly larger than the small intestine. The transverse, descending, and pelvic portions of the colon are the parts most frequently divided.

Retroperitoneal perforations with consequent fecal leakage and cellulitis present difficulties. These posterior perforations may be overlooked because of their minute size or because a hematoma may make the perforation obscure. Injuries of the ascending and descending portions of the colon, which have no mesenteries, are frequently followed by serious retroperitoneal infection.

*Infarction.* Infarction is more common in the large bowel than in the small intestine. It may result from wounding or severance of mesenteric blood vessels or it may be due to the tearing away of a segment of bowel from its mesentery.

*Types of Injury to Rectum.* Wounds of the lumbar region, buttocks, perineum and thighs are often complicated by rectal injuries. Rectal lesions vary in size from small perforations, caused by minute

projectiles or fragments of pelvic bone, to extensive lacerations. Digital examination of the rectum may detect a perforation or a spicule of bone which projects into the lumen; in other instances blood on the gloved examining finger may be the only indication of rectal injury. Extraperitoneal wounds of the rectum eventually develop local tenderness and other signs of infection of the perineum.

The rectum may be wounded extraperitoneally, intraperitoneally, or both. Missiles may take a side to side, anteroposterior or semi-vertical course. Beside peritonitis, infection of the perirectal extraperitoneal space is a frequent complication.

The external damage may be very great, with tearing away of a large portion of the gluteal region. The anus and lower portion of the rectum may be completely avulsed or the lumen may be opened on one side only. If the projectile is small, the sphincter may be left intact. There is a danger of gas gangrene in the gluteal muscles with extensive wounds of the buttocks. Wounds involving the sacrum without an opening in the bowel are frequently fatal because of infection of the presacral areolar tissue.

#### CHARACTER OF LESIONS IN DIFFERENT PARTS OF THE COLON

*The Cecum.* Lesions of the colon may vary greatly in type. Experience has established the proper surgical procedure.

Injuries of the cecum may be small enough to permit closure. Some are large enough to necessitate resection and anastomosis, or the creation of an artificial anus. An ileocolostomy may be performed occasionally. However, in general, an artificial opening, composed of ileum and colon, has proved undesirable.

#### CASE REPORTS

The patient was shot by a rifle bullet in action with the enemy. The wound of entry was in the right lower abdomen and the wound of exit was high in the right buttock. (Fig. 2A.) First aid was administered at a Battalion Aid Station where an evisceration of



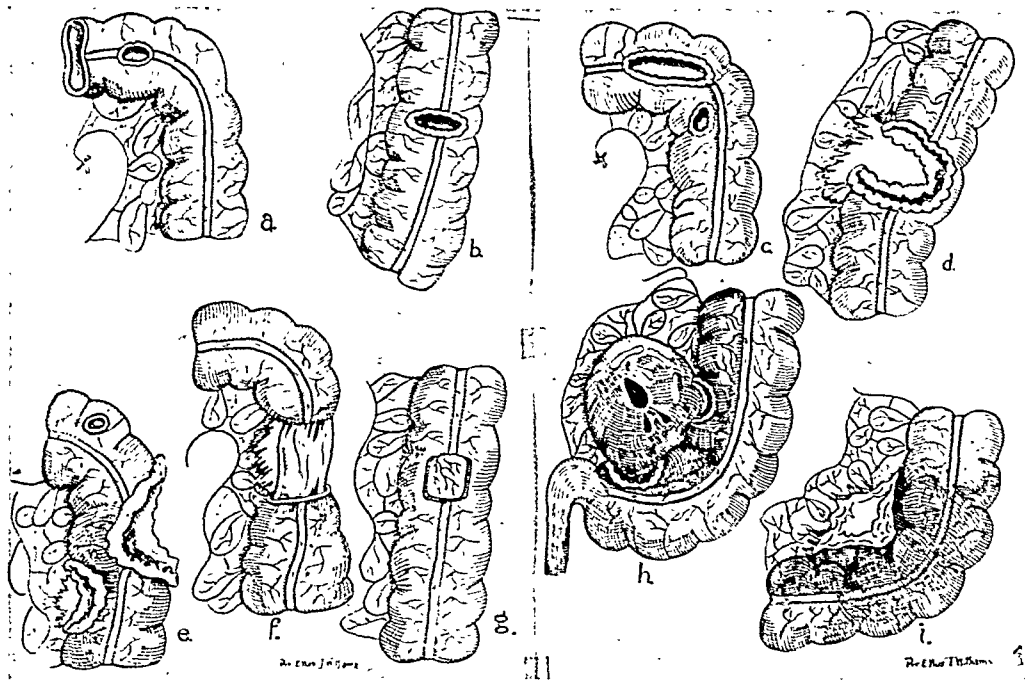


FIG. 1. Various types of injuries of the large intestine. *a*, Single punctate wound; *b*, single transverse laceration; *c*, closely situated lacerated and punctate wounds; *d*, almost complete division of the colon; *e*, multiple lacerated and punctate wounds; *f*, serosa, muscularis and mesentery have been stripped back; *g*, rupture of muscular coat and ulceration of mucous membrane are likely to be caused by air or water blast; *h*, hematoma between leaves of mesentery may hide a wound of the colon; *i*, wound and stripping of the mesentery with damaged blood supply and infarction of wall of colon.

small intestines, through the abdominal wound was found. Wounds were débrided and an exploratory laparotomy was performed at a Field Hospital. Extensive lacerations of the cecum and proximal part of the ascending colon, and a retroperitoneal hematoma were found. A resection of the cecum, appendix and five inches of the ascending colon was performed. A Mikulicz type of colostomy was made with ileum and remnant of the ascending colon. (Fig. 2B.) The colostomy was made in the exploratory wound. The retroperitoneal hematoma was drained through the right lumbar region. There was a moderate maceration of skin and moderate sepsis about the colostomy. The nutritional state of the patient was good. Extensive edema of the colostomy was treated by a firm binder and by having the patient lie in a prone position most of the day. Edema subsided. Five weeks after injury clamps were applied to the colostomy spur and one week later the colostomy was closed. Recovery was uneventful.

In some cases resection may be so extensive that it is not feasible to perform an

exteriorization of the bowel. An anastomosis, with a simple proximal colostomy, will suffice.

The patient was shot by a fragment of an 88 mm. shell in action with the enemy. The wound of entry was in the right lower abdomen and the wound of exit was in the right flank. An exploratory laparotomy revealed multiple perforating wounds of the cecum and ascending colon, and a retroperitoneal hematoma. A resection of a small portion of the cecum and the entire ascending colon was performed. An end-to-end anastomosis was made between the end of the cecum and the transverse colon. A simple colostomy was then made in the redundant cecum proximal to the anastomosis. The colostomy was made in the upper part of the exploratory wound. Extensive sepsis developed in the exploratory wound and a moderate amount of maceration developed in the skin about the colostomy. Sepsis was controlled by chemotherapy and wet dressings. The macerated skin healed with aid of zinc oxide ointment. The nutrition of the patient remained good throughout. The colostomy was closed

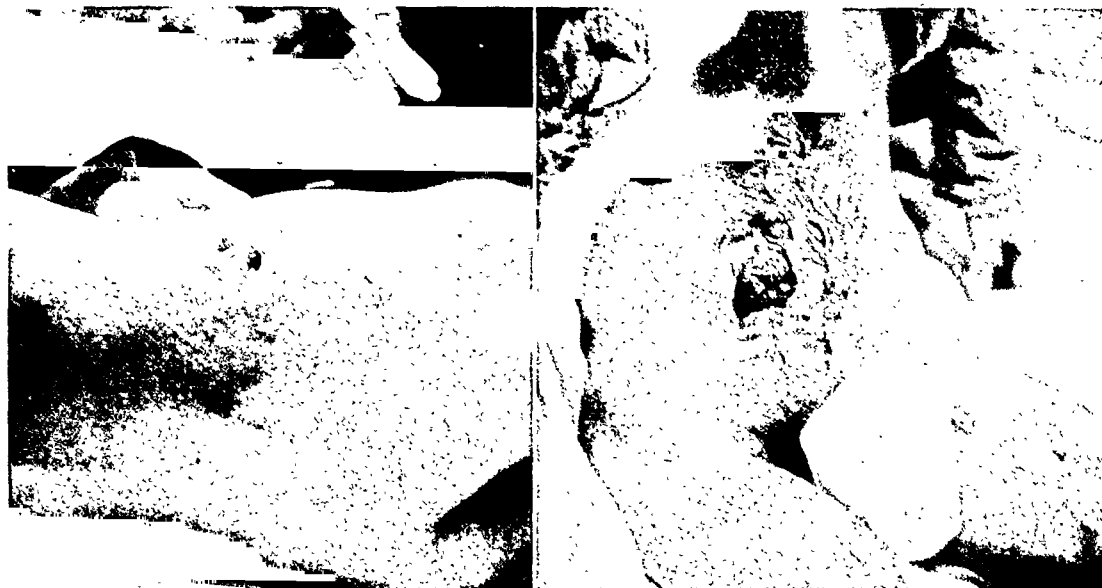


FIG. 2. A, wound of exit high in right buttock; B, ileocolostomy in center of exploratory wound is edematous. There is extensive sepsis of exploratory wound.

eight weeks after injury, by suturing the anterior wall. Recovery was uneventful.

The wounded cecum may be exteriorized as a simple cecostomy or the cecum and proximal part of the ascending colon may be exteriorized as in a Mikulicz type of colostomy.

The patient was shot in the abdomen by fragments from an 88 mm. shell. The wound of entry was in the right lower abdomen. The wound of exit was in the right flank. (Fig. 3A.)

An exploratory laparotomy was performed at an Evacuation Hospital. Multiple wounds of the ileum and a large laceration of the cecum extending into the ascending colon were found. A resection of six feet of ileum and anastomosis were performed. A Mikulicz exteriorization of the injured cecum and ascending colon as performed through a stab wound in the right lower quadrant of the abdomen. (Fig. 3B.) The exploratory wound healed without infection and the stab wound through which the colostomy was performed developed no gross sepsis. Bowel function was normal. Recovery was uneventful.



FIG. 3. A, wound of exit in right lumbar region; B, colostomy in a stab wound is edematous. Exploratory wound has healed without sepsis.



FIG. 4. Multiple wounds of the abdomen, due to an explosion of a grenade at close range. Injured colon is exteriorized through a stab wound. Exploratory wound has healed without sepsis.

#### ASCENDING AND DESCENDING COLON

The ascending and descending portions of the colon may be considered together, as neither has a mesentery. Wounds of these parts of the large intestine may be completely intraperitoneal or extraperitoneal or a combination of the two. The lesions are perforations, splits, tears or complete divisions. Perforations most commonly occur in side to side wounds, and complete divisions in the anteroposterior wounds. Wounds of the ascending colon are of more frequent occurrence than these of the descending colon and the comparative rarity of wounds of the descending colon, observed in the hospital, is probably accounted for by the fact that this part of the colon lies so deep that a missile passing from side to side traverses a coronal plane, situated so far back in the body, as to involve the spinal column and great vessels. In addition, because the descending colon usually is much smaller than the ascending colon, it offers less exposed surface. The intraperitoneal wounds of the vertical colon are usually easily located and dealt with if a suitable incision has been made, but the extraperitoneal wounds, which may be small and

valvular, are difficult to find because they lie in a mass of areolar tissue and may be obscured by a hematoma.

In most cases, with retroperitoneal hematoma, the injury to the colon is obvious.

The patient was shot by a pistol bullet in the abdomen, in action with the enemy. The wound of entry was in the right lumbar region and the wound of exit was in the right thigh. An exploratory laparotomy revealed two perforations of the ascending colon just distal to the cecum and a large retroperitoneal hematoma. The hematoma was drained through the wound in the right lumbar region. The injured ascending colon was exteriorized by Mikulicz method after cutting the posterior peritoneum. The colostomy was performed through the exploratory wound. The wound became septic and a partial dehiscence developed. Sepsis of the wound responded to wet dressings. The gaping wound was closed by secondary suture. Four weeks after injury the colostomy spur was clamped and one week later the colostomy was closed. Bowel functions are normal.

Wounds of large mesenteric blood vessels may result in hemorrhage into the peritoneal cavity besides occasionally forming hematomas in the retroperitoneal spaces or between the leaves of the mesentery.

The patient received multiple wounds of his chest wall and abdomen when a grenade exploded in his right hand. (Fig. 4.) His right hand was blown off. The middle, ring and little fingers of the left hand were blown off. Severe injury to his right eye required enucleation. An exploratory laparotomy revealed a perforating wound of the stomach, a perforating wound of the jejunum, twelve perforating wounds of the ileum and two perforations of the ascending colon. A large intraperitoneal hemorrhage was found, due to a tear in a mesenteric vein. This injured vein was ligated. The perforations in the stomach, jejunum and ileum were sutured. The injured ascending colon, close to the hepatic flexure, was exteriorized by the Mikulicz method through a stab wound in the right upper abdomen. Six weeks after injury the colostomy spur was clamped and eight days later the colostomy was closed. It is interesting to note that there

was no gross sepsis of the exploratory wound or of the stab wound. Bowel functions are normal.

A colostomy must be closely watched at all echelons. Hemorrhage has occurred from some colostomies in transit. A colostomy may retract, even when closely watched, and cause sepsis which may endanger the life of a patient.

The patient was shot in the abdomen by a rifle bullet, in combat with the enemy. The wound of entry was in the right lower abdomen. The wound of exit was in the right lumbar region. There was an evisceration of small and large bowel through the wound in the right lower abdomen. Sulfadiazine was given at the Battalion Aid Station and continued in each echelon. An exploratory laparotomy was performed at an Evacuation Hospital. Perforations were found in the hepatic flexure and in the ascending colon. The wounds in the colon were sutured and a Mikulicz colostomy was performed proximally with the redundant cecum through a stab wound in the right lower abdomen. Four weeks after injury the patient was transferred to a General Hospital. At the time of admission to the General Hospital the patient's temperature was 103°F., pulse was 140 and blood pressure was 100/56. On examination the lateral part of the colostomy was found to have retracted beneath skin, fascia and muscle, so that fecal material was draining retroperitoneally into the lumbar region and pelvis. A clamp was placed on the lateral wall of the colostomy to prevent retraction. Three units of plasma and 2,000 cc. of 10 per cent glucose were given daily for two days. Within twenty-four hours, the patient had recovered from shock and on the following day, under pentothal anesthesia an incision was made in the lumbar region and a cigarette drain was inserted into the pelvis. Organisms cultured from wound were sulfadiazine sensitive. Sulfadiazine therapy was continued. Sepsis gradually subsided. Four weeks after admission to the General Hospital the colostomy spur was clamped and cut, and six days later the colostomy was closed. The patient made a complete recovery.

A complication which has been found to accompany some abdominal wounds is homologous serum jaundice. Homologous

serum jaundice is an entity in which investigation is now being conducted, in an attempt to differentiate it from infectious hepatitis. It is so called because it occurs only when human serum, plasma or blood has been used. The etiology is probably a filtrable virus. Irradiation of the contaminated plasma kills the virus. Homologous serum jaundice may gradually subside or the disease may progress to death. In the more serious cases ascites is found. In fatal cases the liver at autopsy, resembles that found in acute yellow atrophy. From present evidence homologous serum jaundice and infectious hepatitis seem to be the same disease, despite attempts made to differentiate them.

The patient was injured by a fragment of an 88 mm. shell. The wound of entry was in the right lower abdomen. The wound of exit was in the right flank. At a Battalion Aid Station the patient was found to be in shock, was given two units of plasma and initial care of his wounds. At an Evacuation Hospital 1,000 cc. of stored blood and two units of plasma were given. At exploratory laparotomy, two penetrating wounds of the ascending colon were found, about three inches distal to the cecum. A Mikulicz type of exteriorization was performed through the exploratory wound. The patient was given sulfadiazine and penicillin therapy and transferred to a General Hospital. The exploratory wound became septic and responded well to wet dressings. Nine weeks after injury clamps were applied to the colostomy spur. One week later, or seventy days after injury, when the colostomy was ready for closure, the patient complained of feeling "grippy." He complained of generalized aches and felt nauseated. Abdominal discomfort and pain were generalized. His temperature was 99.8°F. and pulse was 98. The liver edge was palpable. Four days after onset of symptoms, the patient developed jaundice. Icteric Index was 17. Van den Bergh was indirect with 1.5 units per 100 cc. of serum. The patient was given a high protein diet. Jaundice persisted for seventeen days. This patient later had a closure of his colostomy with no further trouble.

Extraperitoneal wounds of the descending or ascending colon may be difficult to



FIG. 5. A, wound in left lumbar region through which fecal material drained eight days after exploratory laparotomy revealed no injury to the colon. The descending colon was almost surrounded by a retroperitoneal hematoma. B, Devine colostomy was performed eight days after exploratory laparotomy when fecal drainage was discovered in wound of the left lumbar region. The original exploratory wound is healed.

localize and may be missed at laparotomy because the wound may be small or valvular, imbedded in a mass of areolar tissue or obscured by a hematoma. If these wounds are missed at laparotomy, discovered later by fecal drainage or sepsis of the wound, and a proximal colostomy made, the colostomy must not be closed for months or until the wound in the bowel and the sinus tract are healed.

The patient received injuries in the left lumbar region by a fragment of an 88 mm. shell. (Fig. 5A.) There were compound fractures of the left ileum, the left transverse processes of 1, 2, 3 and 4 lumbar vertebrae. Exploratory laparotomy revealed a large retroperitoneal hematoma in the left lumbar region. No wound was found in the small or large bowel. The missile in the lumbar region was removed and the hematoma was drained through the original wound. Eight days after injury fecal drainage was found in the wound in the left lumbar region. A Devine colostomy was made of the right transverse colon. (Fig. 5B.) Thirteen days after colostomy no fecal drainage was found in the lumbar region but a septic discharge was found. Sulfadiazine was continued. No penicillin was used because no penicillin sensitive organisms were found. The colostomy will not be closed for many months or until it can be demonstrated that

the wound in the descending colon has healed by barium enema and that no communication exists between the wound in the lumbar region and the descending colon, by lipiodol injection. It will be even safer to wait until the sinus in the left lumbar region has healed. Barium enema will also demonstrate whether a stricture exists at the site of injured colon or not.

Wounds of the buttocks commonly involve the rectum. However, the ascending or descending colon may be involved with wounds of the buttocks.

The patient was shot by a machine gun bullet in action with the enemy. The wound of entry was in the left buttock, (Fig. 6A) and the wound of exit was in the left lower abdomen. Exploratory laparotomy revealed a large tear in the descending colon near the sigmoid. A Mikulicz exteriorization of the injured bowel was performed through a stab wound, after mobilization of the bowel by undercutting the peritoneum. The exploratory wound healed without complication. (Fig. 6B.) Three weeks after injury clamps were applied to the spur of the colostomy and one week later the colostomy was closed.

Large retroperitoneal hematomas may be found with no complicating bowel injury.

The patient was injured by fragments of an 88 mm. shell, in the left chest, left arm, left

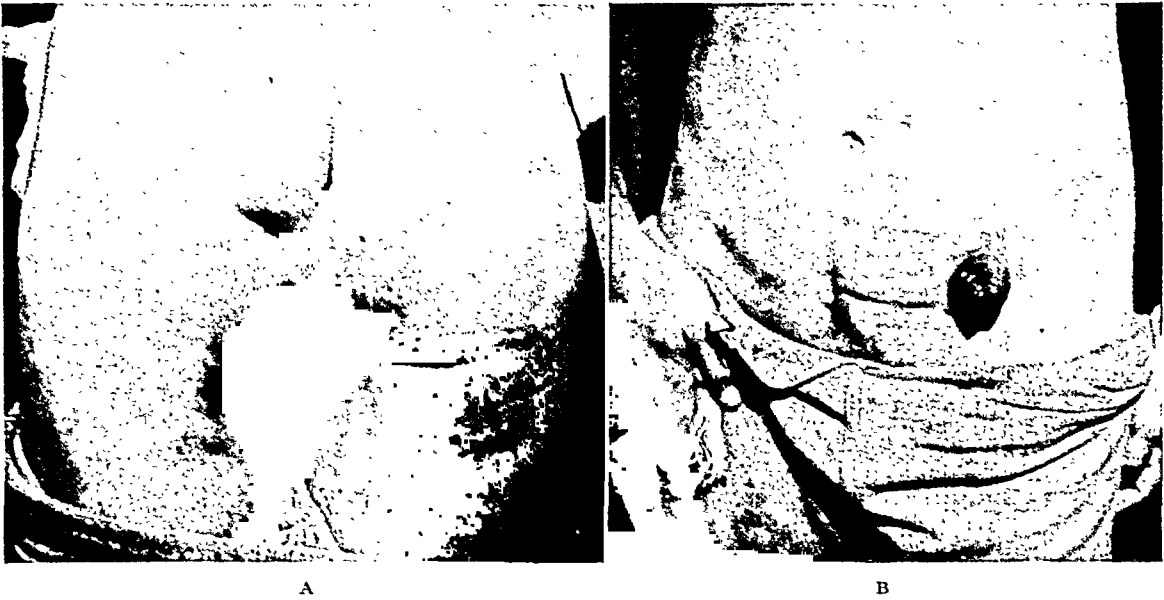


FIG. 6. A, wound of entry in left buttock complicated by a wound of the descending colon; B, colostomy in a stab wound is edematous. Edema was easily controlled by a pressure binder and by the patient lying prone.

flank and left buttock. Exploratory laparotomy revealed a large retroperitoneal hematoma involving the entire left lumbar gutter. Inspection revealed no injury to any of the intra-abdominal contents. The hematoma was drained through the wound in the left lumbar region. Adynamic ileus developed, postoperative, and was easily controlled by Miller-Abbott tube. The wound in the left lumbar region healed without complication.

#### TRANSVERSE COLON

Many types of wounds may involve the transverse colon. True anteroposterior wounds are not very common, since the transverse colon usually is struck obliquely. Wounds of the transverse colon are often accompanied by lesions of the stomach and the small intestine. The posterior surface of this segment of large intestine is sometimes wounded, and injuries in this location are likely to be overlooked. Wounds of the transverse colon are much more easily exteriorized than wounds of the ascending or descending colon. Wounds of the chest may be complicated by wounds of the transverse colon.

The patient was shot in the left chest by a machine gun bullet in action with the enemy. An x-ray revealed two bullets in the left chest and a left pneumothorax. There were signs of

intraperitoneal injury. An exploratory of the chest was performed, two bullets and fragments of clothing were removed. An exploratory laparotomy revealed two perforating wounds of the transverse colon and a retroperitoneal hematoma of the left lumbar region. A Mikulicz exteriorization of the wounded transverse colon was performed through a stab wound. The retroperitoneal hematoma was drained through an incision in the left lumbar region. Edema of the colostomy was treated by a firm binder and by the patient lying prone. The wound in the left chest healed without complication. The abdominal wounds showed no gross sepsis. Four weeks after injury the colostomy spur was clamped and one week later the colostomy was closed. Bowel function was normal.

Small bowel injury frequently complicates injury to the transverse colon.

The patient was shot in the abdomen by a machine gun bullet, in action with the enemy. The wound of entry was in the left parumbilical region. The wound of exit was in the left loin. An exploratory revealed two perforating wounds of the ileum and two perforating wounds of the transverse colon. The wounds in the ileum were sutured and the injured transverse colon was exteriorized by the Mikulicz method, through the exploratory left rectus incision. Severe sepsis and partial dehiscence of the exploratory wound developed. (Fig. 7.) Four weeks after injury the colostomy



FIG. 7. Colostomy in the center of exploratory wound. There is extensive sepsis and partial dehiscence of the exploratory wound.

spur was clamped and one week later the colostomy was closed and the dehiscence was repaired.

When exteriorization cannot be performed it may be feasible to suture wounds of the colon and perform a proximal colostomy. Extensive intra-abdominal arterial hemorrhage may be encountered with wounds of the large bowel.

The patient was shot in the abdomen by a machine gun bullet. The wound of entry was in the left parumbilical region and the wound of exit was in the left lumbar region. At exploratory laparotomy, four perforating wounds of the ileum were found and two perforating wounds of the transverse colon. There was an extensive intra-abdominal hemorrhage from a lacerated gastroepiploic artery. The artery was ligated. The wounds of the small bowel were sutured with a single layer of sutures. The wounds of the large bowel were sutured with a double layer of sutures and a colostomy was performed. Eight weeks later barium enema revealed no stricture in the large bowel. The colostomy was closed extraperitoneally.

#### HEPATIC FLEXURE

The hepatic flexure is usually easy to expose and repair because of its superficial location. Its form makes it susceptible to multiple injuries.

The patient was struck in the abdomen by a fragment of an aerial bomb. The wound of entry was in the right upper abdomen and the



FIG. 8. Colostomy in the center of exploratory wound. Sepsis of exploratory wound and a ventral hernia developed.

wound of exit was in the right flank. At exploratory laparotomy two perforating wounds of the hepatic flexure were found. The injured hepatic flexure was exteriorized by the Mikulicz method. Five weeks after injury the colostomy spur was clamped and nine days later the colostomy was closed.

#### SPLenic FLEXURE

Because of its position and fixations, the splenic is the most difficult part of the large intestine to examine and to repair and mobilization of it may be necessary to permit satisfactory inspection or operative procedure. Injuries of the small bowel frequently complicate injuries of the splenic flexure.

The patient was shot in the left lumbar region by a fragment of an 88 mm. shell in action with the enemy. At exploratory laparotomy three perforations of the ileum were found and a perforating wound of the splenic flexure. The wounds of the small bowel were sutured with a single layer of sutures and the wound of the large bowel was sutured with a double layer of sutures. A Mikulicz colostomy of the transverse colon, proximal to the splenic flexure was made. Eight weeks after injury, a barium enema revealed no stricture of the colon. After proper preparation, the colostomy was dis-

sected and an end to end anastomosis performed. Post operative course was uneventful.

### SIGMOID

The sigmoid colon is anatomically more like the small intestine than any other part of the colon, and the lesions of the sigmoid colon are somewhat similar to those of the small intestine. There may be slits, perforations, or complete divisions and, next to the injuries of the transverse colon, wounds in this segment of the large intestine are most often complicated by injuries of the small bowel. The frequency of associated fracture of the pelvis increases the gravity of wounds of the pelvic colon. The mobility of the sigmoid usually makes injuries to this part of the bowel amenable to exteriorization.

Peritonitis has been encountered with injuries to the large bowel but has not been accompanied by the high mortality of peritonitis in World War I.

The patient was shot by a machine gun bullet in the left buttock, in action with the enemy. At celiotomy four lacerated wounds of the distal sigmoid were found. One laceration measured two inches long. Fecal contamination of the peritoneal cavity was found. A bullet was removed from the subcuticular region of the right groin. The wounds in the sigmoid were sutured. A Mikulicz colostomy was performed in the sigmoid, proximal to the wounds in the bowel. The patient developed diffuse peritonitis. A culture from the peritoneum revealed hemolytic streptococci, non-hemolytic staphylococci and *Bacillus coli*. The streptococci were penicillin sensitive. Sulfadiazine and penicillin were given. The patient recovered from general peritonitis without residual abscess. The wound of the buttocks, measured 2 by 2 inches and became septic. The colostomy will not be closed for at least twelve weeks after injury and then only if barium enema shows no perforation and no stricture, and lipiodol injection of the sinus in the left buttock shows no communication with the sigmoid. It will be safer to wait until the sinus tract of the left buttock heals before the colostomy is closed. The colostomy will be closed by dissection and end-to-end anastomosis, intraperitoneally.

Wounds of the sigmoid are very frequently complicated by wounds of the small bowel. Small wounds of the small bowel may be treated by one layer of sutures.

The patient was injured when a fragment of an 88 mm. shell penetrated his left lower abdomen. At celiotomy eight large lacerations in the ileum and six perforations of the distal sigmoid were found. A metallic foreign body was removed from the peritoneal cavity. Two feet of ileum were resected and end-to-end anastomosis performed. The six perforations of the sigmoid were sutured with a double layer of sutures and a Mikulicz colostomy was performed in the sigmoid proximal to the injured sigmoid in the exploratory wound. Sepsis of the wound and a ventral hernia developed. (Fig. 8.) Eight weeks after injury the patient complained of abdominal pain and a "grippy" feeling. The patient was not jaundiced. However, blood studies revealed that he had an icteric index of 11 and indirect Van den Berg of 1 unit per 100 cc. of serum. The patient had received four units of plasma nine weeks previously, and developed a classical picture of homologous serum jaundice. He completely recovered from the homologous serum jaundice in six weeks. The colostomy was then closed by end-to-end anastomosis, and the defect in the abdominal wall was repaired.

The pelvis is frequently fractured with wounds of the sigmoid. This complicates injuries to the sigmoid still further because bony spicules may perforate other parts of the intestinal tract or osteomyelitis may develop.

The patient was injured in combat when a fragment of an 88 mm. shell penetrated his lower abdomen. An x-ray revealed a foreign body imbedded in the sacrum. At laparotomy a large hematoma was found in the mesentery of the sigmoid. The adjacent sigmoid was very dark and apparently devitalized. The devitalized bowel was exteriorized by the Mikulicz method. One month after injury, the foreign body was removed from the sacrum. Pus was found about the missile. Two weeks later there were x-ray signs of osteomyelitis of the sacrum. This patient had been given sulfadiazine continuously since first aid treat-



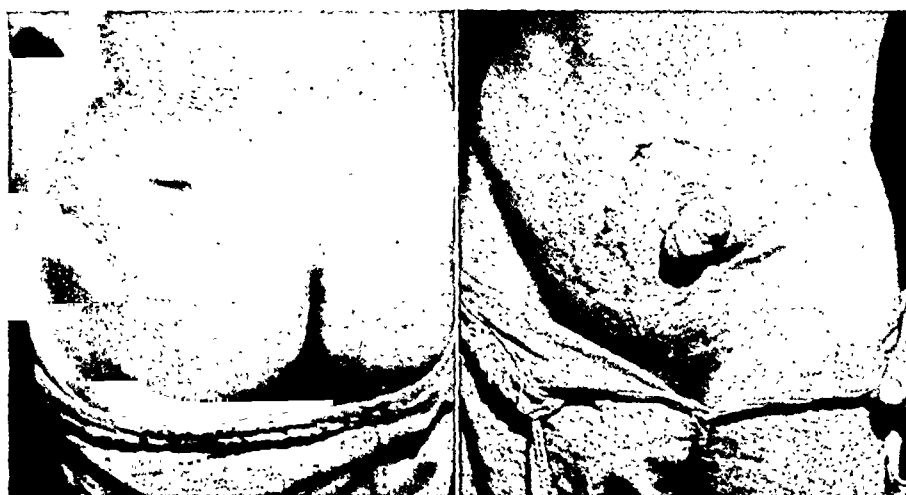


FIG. 9. A, wound of buttock was complicated by wounds of the rectum and urinary bladder; B, sigmoid colostomy proximal to unsutured extraperitoneal wound of the rectum. Cystostomy wound is healed. Colostomy will not be closed for at least six months after injury.

ment. In four weeks all purulent drainage had ceased and two weeks later the wound over the sacrum was healed. Repeated x-ray show a healing of osteomyelitis of the sacrum. Eight weeks after injury clamps were applied to the colostomy spur and five days later the colostomy was closed.

Wounds of the sigmoid may be complicated by rents in the mesentery of the sigmoid. This condition may be accompanied by a large hemorrhage.

This patient was injured when a fragment of an 88 mm. shell penetrated his left lower abdomen. At celiotomy a four-inch laceration of his sigmoid, and a rent in the mesentery four inches long and three inches wide were found. A large intra-abdominal hemorrhage was also found. The bleeding vessels in the sigmoid mesentery were ligated. The injured and devitalized sigmoid was exteriorized by the Mickulicz method. The patient recovered from shock with 2,000 cc. of stored blood and two units of plasma. Three weeks after injury the colostomy was closed by end-to-end anastomosis. Recovery was uneventful.

#### RECTUM

Wounds of the buttocks, thighs and perineum are frequently complicated by wounds of the rectum. Wounds of the rectum are often complicated by wounds of

the bladder, the pelvic colon, and less frequently, injuries of the small bowel.

Rectal lesions vary in size from small perforations, caused by minute projectiles or fragments of pelvic bone, to extensive lacerations. It is sometimes possible, by means of digital examination of the rectum, to detect a perforation or a spicule of bone which projects into the lumen; in other instances blood on the gloved examining finger may be the only indication of rectal injury. Eventually local tenderness, along with other evidences of infections of the perineum indicate that there has been an extraperitoneal wound of the rectum.

Injuries to the rectum above the peritoneal diaphragm are frequently complicated by peritonitis. Rectal injuries below the pelvic diaphragm may be complicated by perirectal infections.

The following aspects of rectal wounds must be considered: (1) The external damage may be very great with tearing away of a large portion of the gluteal region. The anus and lower portion of the rectum may be completely avulsed or the lumen may be opened on one side only. If the projectile is small, the sphincter may be left intact. Although even extensive wounds of the buttocks are not necessarily serious, there is a danger of gas gangrene

in the gluteal muscles. Sulfadiazine and penicillin have done much to keep the incidence of gas gangrene low and have also proved of great value as therapeutic agents. (2) The rectum may be injured extraperitoneally, intraperitoneally, or both. Missiles which cause the injuries may take a side to side, anteroposterior or semi-vertical course. The side-to-side wounds are deceptive, their posterior situation suggesting that the missile has missed the bowel.

Wounds involving the sacrum without an opening in the bowel are frequently fatal because of infection of the presacral areolar tissue; however, pieces of shell protruding into the rectum on its posterolateral aspect have been removed and recovery has followed without any further surgical procedure.

Wounds of the buttocks are frequently complicated by injuries to the rectum. With wounds of the rectum which are not sutured and a proximal colostomy is performed, the colostomy must not be closed for six months and then only if the rectal wound has been proven to be healed.

The patient was shot in the right and left buttocks by rifle bullets in action with the enemy. An x-ray revealed a bullet anterior to the right sacroiliac joint. No fracture of the sacrum or ileum could be detected. The patient bled from the rectum. Digital examination of the rectum revealed a small wound on the posterior rectal wall at about the middle of the sacrum. A Mikulicz colostomy of sigmoid was performed. No attempt was made to close the small wound in the rectum. The colostomy will not be closed for at least six months after the injury and then only if proctoscopic examination proves the wound in the rectum to be healed.

Wounds of the rectum are frequently complicated by wounds of the urinary bladder. With wounds of the rectum and bladder in which a colostomy has been performed, the colostomy should not be closed for at least six months or until the wounds of the rectum and bladder have been proven to be healed.

The patient received wounds of the left buttock from fragments of an 88 mm. shell. (Fig. 9A.) The patient was found to be draining urine and fecal matter from the wound of the left buttock. An exploratory laparotomy revealed no wound of the rectum, intraperitoneally. A urethral catheter was inserted in the bladder. A double barrel colostomy of the sigmoid was performed. Two days later a suprapubic cystostomy was performed and a wound on the posterior aspect of the bladder was sutured. A foreign body was removed from the bladder. Two weeks later the suprapubic catheter was removed and a urethral catheter was inserted. Four weeks later the suprapubic wound was healed and the urethral catheter was removed. (Fig. 9B.) The colostomy will not be closed until six months after injury and then only if the wounds of the rectum are proven healed.

Injury to large blood vessels which supply the rectum may result in delayed and intermittent hemorrhage which may prove fatal.

The patient received a wound of his left lumbar region by a fragment of an 88 mm. shell in combat with the enemy. The patient drained urine from his rectum and from the wound in the left lumbar region. An exploratory laparotomy, revealed spillage of fecal material and about one pint of blood in the peritoneal cavity. No bleeding vessel was found. Pelvic diaphragm of peritoneum was lacerated. No wound of intraperitoneal surface of the rectum was found. A Mikulicz colostomy of the sigmoid was performed and a urethral catheter was inserted into the bladder. Two days later a suprapubic cystostomy was performed and a wound on the posterior wall of the bladder was sutured. The patient was given penicillin and sulfadiazine. An x-ray revealed a hole in the center of the sacrum and a metallic foreign body just below and medial to the lower border of the acetabulum of the right pelvis. The patient had no further sign of hemorrhage until three and one half weeks after injury when a hemorrhage of about one quart of blood occurred from the rectum. A pectinotomy was performed and the rectum was packed. The packing was inserted from the anus to the colostomy opening. On the following day the patient had signs of meningitis. The spinal fluid examination was that of purulent menin-

gitis. The rectal pack was removed two days after insertion. Two days later a second rectal hemorrhage of about one pint occurred. A bleeding vessel was clamped and ligated high on the posterior wall of the rectum. A small laceration high on the posterior wall of the rectum was sutured. On the following day a third massive rectal hemorrhage of bright red blood occurred. Digital examination revealed a large retrorectal hematoma. Hemorrhage ceased spontaneously. It was evident that the hemorrhage was occurring from the superior hemorrhoidal artery. A decision was made to get the patient in operable condition if possible, with transfusions of whole blood. During the process of transfusion a fourth hemorrhage occurred. An amputation of the rectum with a perineal approach and a ligation of the superior hemorrhoidal artery was performed. The patient succumbed about one hour after operation. A rent in the superior hemorrhoidal artery was demonstrated in the surgical specimen. Autopsy showed a hole in the center of the sacrum; a healing fibrous peritonitis, acute purulent meningitis, a wound of the bladder and large retrorectal hematoma. The rectum and sigmoid were almost surrounded by a hematoma measuring 10 cm.  $\times$  5 cm. A probe inserted into the superior hemorrhoidal artery at the promontory of the sacrum passed into the hematoma. The wound in the lumbar region communicated with the hole in the sacrum, the hematoma and the healed wound on the posterior wall of the bladder.

*Treatment. Lesions of the large intestine:* Experience has proved the best methods of treating injuries of the large intestine. Two general principles are to be followed (1) Exteriorization is performed whenever possible. (2) If exteriorization is not possible, a proximal colostomy and suturing of the bowel, if possible, is performed.

In order to avoid overlooking wounds of that part of the large intestine which lacks a mesentery, the segment in which injury is suspected must be mobilized. The Trendelenburg position facilitates exposure and repair of injuries of the pelvic colon.

able to shut off the cavity by a line of the anterior surface of the abdominal wall, and In the presence of hemorrhage it is impossible to determine the absence of colonic injury. In the absence of possible injury, there is no drainage. Some British surgeons perform a colostomy proximal to the injured vertical colon in such circumstances. However, it is better to first débride the lumbar wound, remove the hematoma, pack the wound. If it persists and cannot be removed, perform a laparotomy, inspect the abdominal cavity, and if there is no evidence of damage to the rectum, perform a proximal colostomy.

Proximal colostomy must be complete. It is not sufficient in the presence of wounds of the large intestine which sepsis develops. It is a situation with rectal injury in which cases in which fecal colonic wounds.

Wounds of the large intestine are treated by simple exteriorization. If the involved portion which is not viable, the injured bowel is exteriorized and a loop colostomy with a loop of bowel beneath the loop to the skin. There is neither skin closure beneath the loop. An incision is made in the bowel wall, and the posterior wall of the rectum is resected. When this colostomy is closed, an elliptical incision is made in the skin about the colostomy, and the excised from colostomy is carried through fascial layers and closed by two layers of suture. The peritoneum is not entered, and the wall is closed over the wound, and through sutures.

When a colostomy is

rated by about two inches so that each end may be covered by a separate dressing, and in order that feces may not enter the distal loop. Before re-establishing colonic continuity, both loops should be irrigated daily with saline or a permanganate solution.

For one week before the operation the patient should be given a low residue diet and sulfadiazine. In some cases penicillin may help. At operation both loops of the colostomy should be thoroughly irrigated with soapy water and finally with saline. Both ends of the bowel are mobilized. Colonic continuity is then established by an intraperitoneal end to end anastomosis. Two layers of sutures are used, a Connell stitch of chromic catgut 00 size, and a Cushing serosal layer of fine silk. Peritoneum and transversalis fascia or posterior sheath of the rectus are sutured with chromic catgut size 1. Through-and-through sutures are inserted through skin, anterior sheath of rectus and rectus muscle of each side, and are left untied for four days. The wound is dusted with sulfanilamide powder and a vaseline dressing is applied. Postoperatively, the patient is given intravenous fluids and nothing by mouth for forty-eight hours. Fluids by mouth are given for two days, then low residue foods, and finally a normal diet. Chemotherapy is continued as is indicated.

A Mikulicz colostomy used for exteriorizing an injured bowel or as a colostomy proximal to the injured colon, was frequently used in the early stages of the war. The reasons for discarding the Mikulicz procedure are the incidence of intestinal obstruction, rotation of the colostomy carrying the mesentery between the loops in a small per cent; and because with the two stomata in such proximity, the same dressing covers both openings and feces in the distal loop is a major factor in the persistence of fistulas from the lower colon and rectum to sites about the lumbar region, buttocks, or pelvis. If a Mikulicz procedure has been performed at a forward echelon, the safest method of closure is by

mobilization and end to end anastomosis, intraperitoneally. However, in our series of forty cases, eighty per cent were suitable for clamping of the spur, closure of the anterior wall and a plastic repair of the abdominal wall. In closing the colostomy the aim is two-fold: (1) To avoid infection; (2) to restore all layers of abdominal wall over the sutured bowel and thus avoid a hernia. A procedure has been performed which has satisfactorily met these requisites, in all our cases, closed to date. (Fig. 10A.) An elliptical incision is made about the colostomy, for a distance of about 1 cm. from the edge of the bowel. (Fig. 10B.) The incision is carried through skin and fascia of the external oblique or anterior sheath of the rectus. Granulation tissue is excised from the edge of the bowel. (Fig. 10C.) The colostomy is then closed by two layers of sutures, a layer of Connell sutures with chromic gut size 00 and a layer of Cushing sutures with fine silk. (Fig. 10D.) It has been proven that a more satisfactory closure is accomplished if the fascia of the external oblique is incised besides the skin. When the colostomy is closed the wound is irrigated with saline as a precaution against contamination. The deep layer of fascia is bluntly dissected from the underlying peritoneum for a distance of 1 cm. to 2 cm. around the entire wound. This deep layer may be transversalis, transversus fascia, or posterior sheath of the rectus, depending upon the location of the colostomy. A shelf of abdominal wall now exists, beneath which the sutured bowel may be placed. (Fig. 10E.) Silk through-and-through sutures are placed through all layers of abdominal wall down to the peritoneum. The wound is dusted with sulfanilamide crystals. The sutures are untied. However, a decrease in the extent of the gape of the wound may be accomplished by tension on the sutures, as by tying a single loop. (Fig. 10F.) A vaseline gauze dressing is placed on the wound. The wound is not inspected until the fourth day post operative. If the wound is clean at that time it is closed by simply



FIG. 10. A, sigmoid colostomy ready for closure.

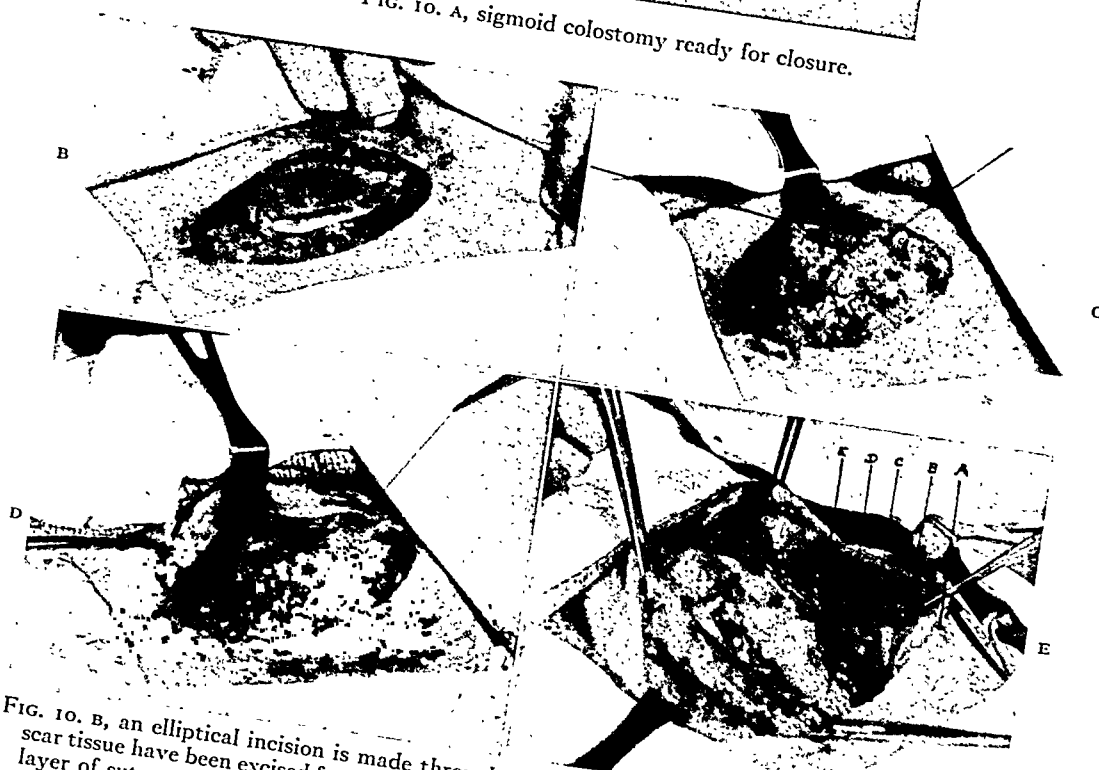


FIG. 10. B, an elliptical incision is made through skin and anterior sheath of rectus; C, skin and scar tissue have been excised from the colostomy edge; D, colostomy has been closed by a double layer of sutures; E, posterior sheath of rectus has been bluntly dissected from peritoneum. A shelf of abdominal wall, fascia-muscle-fascia, 1 to 2 cm. wide is constructed. A, skin; B, anterior sheath of rectus; C, rectus muscle; D, posterior sheath of rectus; E, peritoneum.

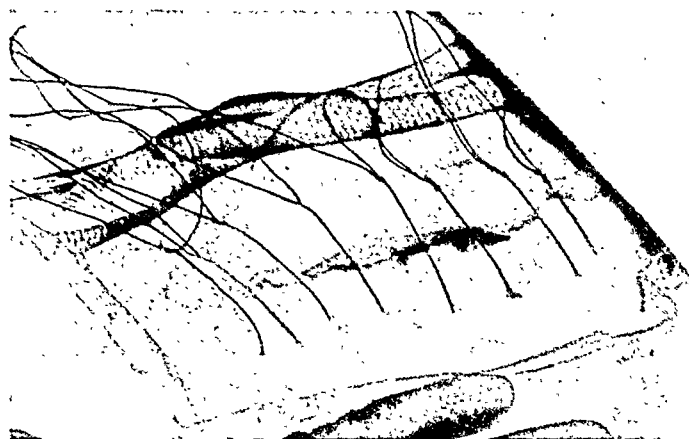


FIG. 10. F, sutures are carried through skin, anterior sheath of rectus, rectus muscle and posterior sheath of rectus on each side. Sutures are united or tied loosely for four days. On the fourth day, if wound is clean, sutures are tied tightly, restoring all layers of abdominal wall over the colostomy.

tying the sutures, under penthotal anesthesia. If the wound is grossly septic after operation, closure of the wound is delayed until sepsis subsides. By this method all layers of abdominal wall, down to peritoneum have been sutured over the closed bowel. Sepsis has been no problem and in no case has a hernia been found post operative.

The Devine colostomy has proved valuable. This procedure avoids all objections to the Mikulicz colostomy. However, it is more time consuming than the Mikulicz procedure. In this operation, the colon is transected, the two loops are sutured along a longitudinal band. The two ends are then brought out through separate stab wounds on either side of the primary incision. A special long-armed spur crusher is used to necrotize the septum. The ends are inverted.

Cecostomy is, in general, of little value. Wounds involving the cecum alone or the cecum and ileum require repair of ileum and cecostomy i.e. exteriorization of the defect. Ileostomy should be avoided and a double-barrelled opening of ileum and cecum has proved to be undesirable.

Gordon-Taylor enumerates the indications for resection.<sup>1</sup> The cecum or colon is in a state of infarction.<sup>2</sup> There is extensive separation of the bowel from its mesocolon or vascular supply, especially if

the mesocolon is also the site of a hematoma or is actively bleeding.<sup>3</sup> The vitality of the bowel is extinguished by a large piece of metal or other fragment hurled with the cyclopean force of a modern high explosive.<sup>4</sup> The wound of the large intestine is of such magnitude, or the surgical approach to the part of the colon damaged is associated with such difficulty, as to suggest the formation of an artificial anus as a surgical 'pis aller.' However, exteriorization may be performed in many of these situations.

Drainage is important in the treatment of wounds of the large bowel, and it should be instituted when doubt as to the integrity of the suture line exists, as well as in every case of proved or questionable retroperitoneal injury.

Sulfadiazine is used in all cases. Penicillin may be used when organisms which are penicillin sensitive are found.

*Treatment of Injuries of the Rectum.* The treatment of rectal injuries associated with wounds of the buttocks, lumbar region or pelvis, consists of excising all damaged tissue and, when possible, closing the rent in the bowel or sphincter, although sometimes it may be better to lay open the lower end of the canal by dividing the sphincter. If the peritoneum has been opened, the abdominal cavity should be closed off by sutures. Proximal colostomy is necessary for all rectal wounds with free

drainage of the perirectal space by incision of the fascia propria. The wound of the rectum may, or may not be sutured. The missile tract in the buttock is never used to drain the retroperitoneal space.

In some cases of rectal injury it is feasible to leave the rectal wound unsutured and to do a proximal colostomy. In such cases it is extremely important to wait about six months or long enough to make certain that the wound in the rectum and the exterior wound have healed, before closing the colostomy.

When a projectile has traversed the pelvis, exploratory laparotomy should be done. If the peritoneal surface of the rectum has escaped injury, the abdomen can be closed and the rectal wound exposed exteriorly. Anterior extraperitoneal wounds of the rectum can be sutured easily, except when they are deep in the pelvis. The bottom of the rectovesical pouch can be shut off by suturing the peritoneum over it.

#### SUMMARY

The mortality from wounds of the large bowel and rectum will be less in World War II than in World War I, due to the better nutritional state of our soldiers, blood and plasma infusions, chemotherapy and early surgery.

The best method of treating wounds of the colon is by exteriorization, when possible. If exteriorization is not possible, the wounds of the colon should be sutured and a proximal colostomy performed. Resection is rarely indicated.

When colostomy is performed as in exteriorization or as a colostomy proximal to a wound in the distal bowel or as a colostomy proximal to a resected and sutured colon, the colon should be completely transected and the two ends of the bowel brought out on the abdominal wall at different sites. This procedure prevents spillage of fecal material into the distal loop, prevents intestinal obstruction, prevents interposition of a loop of small bowel in a septum, and after proper irrigation of

the proximal and distal loops permits end-to-end anastomosis with ease.

Mikulicz colostomy was commonly used in the earlier stages of the war. In our forty cases, one developed intestinal obstruction and in eighty per cent, it was feasible to clamp the spur and close the colostomy. In twenty per cent it was necessary to mobilize the colostomy, dissect the wedge and perform an end-to-end anastomosis, intraperitoneally.

Devine colostomy avoids the difficulties presented by Mikulicz procedure but is more time consuming.

Edema of the colostomy has been frequently met and may be the cause annoying delay in closure of the colostomy. The edema may be satisfactorily treated by reducing the colostomy into the lumen, applying a firm tight abdominal binder, and by having the patient lie prone most of the day.

A colostomy should not be made through the exploratory incision because of the great incidence of sepsis and dehiscence. A separate stab wound is made for a colostomy.

With injuries of the colon and rectum in which the wounds were not sutured and with combined wounds of the rectum and bladder, where a proximal colostomy was performed, a special problem is presented. Before closing the colostomy it is necessary to wait six months or until the wound of the bowel has been proven healed by proctoscopy or barium enema, and to prove that there is no communication between the exterior wound and the lumen of the bowel by lipiodol injection. Otherwise a recurrence of the fecal fistula may be met.

Cases are presented which show how wounds of every part of the colon and rectum and their complications have been handled at different echelons.

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COLOSTOMY usually is *cecal* or *sigmoid*; it is inguinal, lumbar or ventral, according to the location of the new opening which should not be near the anterior iliac spine or umbilicus. Lumbar colostomy, formerly used, is less accessible and more difficult to keep clean, but may be performed without opening the peritoneum by using the extraperitoneal portion of the descending colon.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).



# MECKEL'S DIVERTICULUM\*

## REVIEW OF LITERATURE AND ANALYTICAL STUDY OF TWENTY-THREE CASES WITH PARTICULAR EMPHASIS ON BOWEL OBSTRUCTION

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IN spite of the fact that the origin and formation of Meckel's diverticulum has been well known and understood since Meckel's publication on this subject, it is believed that before going into the details of this subject that a brief review of the embryological, the pathological and the histological structures of the anomaly may be of interest and value. The literature on Meckel's diverticulum is very extensive. This interesting congenital anomaly has inspired a number of authors, mainly perhaps because of the serious pathological complications involved in a large percentage (20 per cent) of these cases.

Lichtenstein believes that Hildamus (1598) is probably the first to observe this diverticulum. Lavater reported it in 1671, Ruish in 1707 and Morgagni in 1769. Litre reported a diverticulum in a hernia in 1742. However, Meckel is the first to publish an adequate description of this anomaly and to explain its embryological background. He was the first to associate Meckel's diverticulum with the omphalomesenteric duct. Fabricius tried to explain the formation of Meckel's diverticulum on a mechanical basis. He believed that the pressure of the intestinal content was the probable cause for its formation. The ductus omphalo-entericus or the Vitello-intestinal duct is a slender tube connecting the midgut with the vitelline vesicle or yolk sac during the early weeks of its embryonic life. Persistence of this duct may cause the formation of Meckel's diverticulum in its various forms.

Meckel's diverticulum usually originates from the terminal ileum at its antimesen-

teric border about 20 inches proximal to the ileocecal valve. McMurrich, Tisdall, Robertson, Reed, Abt and Strauss, however, report cases in which Meckel's diverticulum arose from the mesenteric border and its blood supply passing through an own mesentery to the top of the Meckel's diverticulum (Milese). The distance frequently varies from a few centimeters to 192 cm. and the size from a small intestinal outpouching to a large viscus filling almost half the abdominal cavity (Yates). Giant diverticula are rare, however, we find reports concerning them in the literature by Tisdall, Edmonds, Moll and Edwards. The largest one, according to Yates, filled almost half of the abdomen. The question arises whether this was a true diverticulum of congenital origin or a pseudo diverticulum. Some believe (McMurrish and Tisdall) that these large diverticula are probably the remains of both the ductus omphalo-entericus and the yolk sac.

Hadley reports a case of a nine-year old boy with a Meckel's diverticulum about 3 cm. long originating from the appendix. This was attached to the umbilicus by a vascular band. The mucous membrane was similar to that of the colon. Carlson reports a case of a thirty-eight-weeks old fetus in which two Meckel's diverticula were found, one 50 cm. and the other 70 cm. from the ileocecal valve. Kelly states that Meckel's diverticulum has been found in every portion of the bowel (between the duodenum and the colon). The end of Meckel's diverticulum is usually round, it may also be the seat of knobby secondary diverticula. Christie and Doepf-

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ner reported a case of Meckel's diverticulum bifurcating at the end.

The ductus omphalo-entericus or ductus vitello intestinalis or vitelline duct is a fine tube connecting the vitelline vesicles or yolk sac with the midgut during the early weeks of fetal life. In the eighth or ninth week of fetal life the abdomen will close, so forming the umbilicus. The duct becomes obliterated and separates from the intestine. The fetus is about 7 mm. long at that time. If the vitelline duct remains open at its proximal part, the Meckel's diverticulum results, which usually resembles the ileum in its anatomical and histological structures.

A Meckel's diverticulum may remain attached to the umbilicus or its end may hang free in the abdominal cavity or it may be buried in the mesentery. The free end of the diverticulum may become attached at any point within the abdominal cavity, thereby creating a basis for future bowel obstruction. If the external part of the duct should remain open a small umbilical fistula will usually result, fistula omphalo-enterica incompleta externa. Should the entire ductus omphalo-entericus persist, an intestinal umbilical fistula may form. When the cord is tied off, after the infant is born, the duct will also be tied off and in these cases a fecal fistula will result, fistula enterica completa. Should the mucosa of this fistula prolapse the condition created is known as anus praeternaturalis. Kuestner speaks of diverticulum prolapse, Kermauner of eversion of the mucosa from Meckel's diverticulum.

Another type of a complete intestinal umbilical fistula may develop as follows: Meckel's diverticulum may remain attached to the umbilicus; following infection of the umbilicus, the previous blind end of the diverticulum may perforate and form an anus praeternaturalis; the external and internal ends of the ductus omphalo-entericus may end blind, forming an umbilical cyst, enterocystoma.

Cullen thinks, after studying the reported cases of umbilical polyps, that they

are remnants of the omphalomesenteric duct. Anders believes that umbilical tumors may indirectly originate from the ductus omphalo-entericus. If only few (coelom) epithelium persist in the region of the umbilicus, they may become the point of origin for umbilical tumors.

A large percentage of Meckel's diverticula, about 33 per cent, are associated with malformations. This may suggest a primary defect in the germ plasma as a possible etiological factor (Christie).

The obliterated omphalo-entericus duct may form a fibrous cord attached to the umbilicus and ileum and become a cause for bowel obstruction. The fibrous cord may remain attached to the umbilicus or may hang free in the abdominal cavity. It may also become attached to another loop of intestine or to any point of the peritoneum.

According to Kaufman, Meckel's diverticulum is the most common anomaly of the entire intestinal tract. Hilgenreiner and Fehre found one Meckel's diverticulum among fifty to fifty-four autopsies. Kaufman, in a series of 1,600 autopsies revealed about the same percentage. Doepfner finds one in sixty-five autopsies. Anders reveals in a series of 18,330 autopsies only 199 Meckel's diverticula. Curd in 40,439 autopsies 367, an average of only 0.9 per cent; a much lower incidence than that reported by other authors show. Adami 2.7 per cent, Fuchnig 2 per cent and Harbin 2 per cent. Johns Hopkins Hospital reports in 2,600 autopsies fifteen cases of Meckel's diverticulum; Boston City Hospital: 1,382 autopsies eleven cases; Dresden City Hospital: 8,133 autopsies eight cases; and Mitchell, Chicago: 1,635 autopsies thirty-nine cases or 2.25 per cent.

The incidence of Meckel's diverticulum in laparotomies shows similar figures. Bal-four reports in 10,000 laparotomies only fifteen cases of Meckel's diverticulum. McGlannan in 14,000 laparotomies only three cases. Others report larger figures. The general estimation is about 2 per cent incidental findings of Meckel's diverticu-

## Haber—Meckel's Diverticulum

APRIL, 1947

TABLE I

No.	Age	Race	Sex	Preoperative Diagnosis	Postoperative Diagnosis	Pathological Report		Operation	Find- ings Incidental to Oper- ation	Mor- tality
						Gross	Microscopic			
1	53	W	M	Bilateral inguinal hernia, incarcerated, right	Same, incarcerated, Meckel's diverticu- lum in right hernia	Negative	Meckel's diverticu- lum, lined with regu- lar, small intestinal mucosa	Resection of Meckel's diverticulum, repair of right hernia	Yes	No
2	24	W	M	Recurrent chronic ap- pendicitis	Same, Meckel's diver- ticulum	Negative	Lined by small intes- tinal mucosa. Gas- tric mucosa, pyloric glands chronic in- flamed	Appendectomy Resection of Meckel's diverticulum	Yes	No
3	35	W	M	Recurrent chronic ap- pendicitis	Chronic recurrent ap- pendicitis; Meckel's diverticulum	Meckel's diverticulum with multiple diver- ticuli, chronic ap- pendicitis	Small intestinal mu- cosa	Appendectomy Resection of Meckel's diverticulum	Yes	No
4	31	W	F	Acute appendicitis	Acute appendicitis, Meckel's diverticulum	Appendix with fecal- ith pus mucous re- tention, Meckel's di- verticulum	Small intestinal mu- cosa in Meckel's di- verticulum	Appendectomy Resection of Meckel's diverticulum	Yes	No
5	17	W	F	Acute appendicitis	Subacute appendicitis, Meckel's diverticulum	Same	Small intestinal mu- cosa in Meckel's di- verticulum	Appendectomy Resection of Meckel's diverticulum	Yes	No
6	21	W	M	Acute appendicitis	Recurrent chronic ap- pendicitis; Meckel's diverticulum	Negative	Small intestinal mu- cosa in Meckel's di- verticulum	Appendectomy Resection of Meckel's diverticulum	Yes	No
7	39	W	M	Acute appendicitis	Intestinal obstruction due to persistent om- phalo mesenteric ves- sels, Meckel's diver- ticulum, chronic re- current appendicitis	Meckel's diverticulum with marked edema of submucosa	Small intestinal mu- cosa in Meckel's di- verticulum	Appendectomy Resection of Meckel's diverticulum Releasing obstruction, resection of Meckel's diverticulum; appen- dectomy	Yes	No
8	31	W	M	Chronic recurrent ap- pendicitis	Acute appendicitis, Meckel's diverticulum	Same, Meckel's diver- ticulum slightly in- flamed	Gastric mucosa	Appendectomy Resection of Meckel's diverticulum	Yes	No
9	54	W	M	Intestinal obstruction	Intestinal obstruction, gangrene of loop of small bowel due to double knotting of free Meckel's diver- ticulum	Same	No report on mucosa of Meckel's diver- ticulum	Resection of gangre- nous bowel and Meck- el's diverticulum	Yes	Died

	No	43	W	M	Chronic recurrent appendicitis	Pseudomelanosis of appendix, Meckel's diverticulum	No specimen from Meckel's diverticulum			Inversion of Meckel's diverticulum	Yes	No
10												
11		55	W	M	Chronic recurrent appendicitis	Meckel's diverticulum with slight inflammation	Superficial inflammation of Meckel's diverticulum	Lined by small intestinal mucosa	Appendectomy Resection of Meckel's diverticulum	Yes	Yes	No
12		32	W	F	Pelvic inflammatory disease, rectocele	Hematosalpinge, Meckel's diverticulum	Meckel's diverticulum negative	Lined by small intestinal mucosa	Salpingectomy Resection of Meckel's diverticulum	Yes	Yes	No
13		14	W	F	Acute appendicitis	Appendix with adhesions at its base; Meckel's diverticulum	Meckel's diverticulum	Small intestinal, mucosa, large lymph follicles	Appendectomy Resection of Meckel's diverticulum	Yes	Yes	No
14		41	W	M	Intestinal obstruction	Same, due to Meckel's diverticulum, adherent to umbilicus and persistent omphalo mesenteric vessels	Meckel's diverticulum negative	Lined by gastric and duodenal mucosa	Appendectomy Resection of Meckel's diverticulum releasing obstruction	Yes	Yes	No
15		7 mo.	W	M	Incarcerated right inguinal hernia	Meckel's diverticulum strangulated in inguinal hernia	No specimen obtained		Inversion of Meckel's diverticulum	Yes	Yes	No
16		77	W	M	Acute appendicitis possible obstruction	Intestinal obstruction due to Meckel's diverticulum with torsion of bowel	Hemorrhagic Meckel's diverticulum	Lined by small intestinal mucosa right in lymphatic tissue	Resection of Meckel's diverticulum	Yes	Yes	No
17		13	W	M	Intestinal obstruction	Same, due to Meckel's diverticulum and persistent omphalo mesenteric vessels	Meckel's diverticulum adherent to umbilicus, persistent omphalo mesenteric artery	Small intestinal mucosa	Appendectomy Resection of Meckel's diverticulum and persistent omphalo mesenteric vessels	Yes	Yes	No
18		23	W	M	Intestinal obstruction, Meckel's diverticulum	Intestinal obstruction, invaginated Meckel's diverticulum with intussusception	Same, acute hemorrhagic necrosis of Meckel's diverticulum	Small intestinal mucosa	Appendectomy Resection of Meckel's diverticulum and omphalo mesenteric vessels	No	No	No
19		38	W	M	Subacute appendicitis	Obliterated appendix and Meckel's diverticulum	Same, negative	Lined by small intestinal mucosa	Appendectomy Resection of Meckel's diverticulum	Yes	Yes	No
20		22	W	F	Appendicitis, possible pelvic inflammatory disease	Chronic recurrent appendicitis, hemorrhagic, corpus luteum, Meckel's diverticulum	Same	Pancreatic tissue in Meckel's diverticulum	Appendectomy Partial right oophorectomy	Yes	Yes	No
21		25	W	F	Pelvic inflammatory disease, tubo-ovarian abscess	Same, chronic recurrent, appendicitis, Meckel's diverticulum (hydrosalpinx, etc.)	Same, Meckel's diverticulum negative	Lined by small intestinal mucosa	Resection of Meckel's diverticulum Bilateral salpingectomy, fundectomy, appendectomy Resection of Meckel's diverticulum	Yes	Yes	No

TABLE I (Continued)

No.	Age	Race	Sex	Preoperative Diagnosis	Postoperative Diagnosis	Pathological Report		Operation	Findings Incidental to Operation	Mortality
						Gross	Microscopic			
22	8	W	M	Acute appendicitis	Chronic recurrent appendicitis, Meckel's diverticulum	Same, Meckel's diverticulum negative	Small intestinal mucosa	Appendectomy Resection of Meckel's diverticulum	Yes	No
23	26	W	M	Acute appendicitis	Inflammation of Meckel's diverticulum with beginning bowel obstruction	Same	Meckel's diverticulum with gastric mucosa and fresh hemorrhages	Resection of Meckel's diverticulum	Yes	No

lum in laparotomies. However, these figures are inaccurate as only few surgeons make a routine search for Meckel's diverticulum. We see that with slight variations the incidental findings are about 2 per cent.

*Age and Sex Incidence.* According to Greenwald's analysis of his series there were forty-one in males and four in females (91 per cent in male). Doepfner found it in 214 males and 102 in females. This is twice as frequent in the male, which findings correspond to the reports of most authors. Age varies. The youngest reported in the literature was an infant of three months (Schaetz).

Meckel's diverticulum may be present throughout a lifetime without causing any symptoms, as proved by the incidental autopsy findings. This anomaly, however, will always remain a potential source of danger. Fifteen to 20 per cent (Faust) of all the diverticula are subject to pathological changes.

#### CLASSIFICATION

Before going into the details of diagnosis and the different types of pathological conditions found in Meckel's diverticulum a classification may help bring these factors to a clearer understanding. Many classifications have been made and advised; however, we believe a modification of the one given by Greenblatt and his associates may be the one of choice.

- I. Incidental (without disease, lined by small intestinal, ileum, mucosa)
- II. Inflammatory type
  - A. Non-specific (due to trauma, foreign bodies, parasites or idiopathic)
    1. Acute
      - (a) Catarrhal
      - (b) Gangrenous
      - (c) With perforation
    2. Subacute
    3. Chronic
  - B. Specific
    1. Tuberculosis
    2. Typhoid

TABLE II

No. of Cases	Age		Race		Sex	Preoperative Diagnosis	Postoperative Diagnosis in Regard to Meckel's Diverticulum	Pathological Report		Findings Incidental to Operation	Mortality Per Cent
	Youngest	Oldest	White	Colored				Gross	Microscopic		
267	mo.	77 yr.	23	..	17 Male 9 Female	13 Appendicitis 2 Incarcerated hernia 2 Pelvic inflammatory disease 2 Intestinal obstruction 4 Intestinal obstruction and Meckel's diverticulum 1 Meckel's diverticulum 1 Meckel's diverticulum	2 Incarcerated Meckel's diverticulum in inguinal hernia 2 Intestinal obstruction due to Meckel's diverticulum 7 Inflammatory Meckel's diverticulum 3 Invaginated Meckel's diverticulum 1 Invaginated Meckel's diverticulum	Occasional multiple lesions occurring simultaneously Inflammatory Meckel's diverticulum Hemorrhagic Meckel's diverticulum Invaginated Meckel's diverticulum Persistent omphalo mesenteric vessels Double knotting of free Meckel's diverticulum Meckel's diverticulum with multiple diverticuli Meckel's diverticulum adherent to umbilicus Meckel's diverticulum strangulated in inguinal hernia Meckel's diverticulum without gross changes	14 Ileal mucosa 14 Ileal and gastric mucosa 1 Gastric and duodenal mucosa 3 Gastric mucosa 1 Pancreatic tissue 1 Not recorded 1 No specimen	21	0.2

- III. Obstructive type
  - 1. Torsion of volvulus
  - 2. Intussusception (with diverticulum as the starting point)
  - 3. Diverticulum knotting around intestine
  - 4. Bands, remnants of ductus omphalo-entericus and omphalo-entericus vesicles
  - 5. Incarceration in hernia
- IV. Peptic ulceration (due to the presence of ectopic gastric tissue)
  - 1. Ulcer
  - 2. Penetrating ulcer (with and without hemorrhage)
  - 3. Perforating ulcer
- V. Tumors
  - A. Benign
    - 1. Adenoma
    - 2. Enterocystoma
    - 3. Mesodermal tumor
    - 4. Carcinoid
    - 5. Myoma
    - 6. Lipoma
    - 7. Neuroma
    - 8. Papilloma
  - B. Malignant
    - 1. Carcinoma
    - 2. Sarcoma
  - C. Heterotopic tissue
    - 1. Gastric
    - 2. Pancreatic, etc.

#### DIAGNOSIS

The correct preoperative diagnosis of Meckel's diverticulum is rarely made. Harbin reports one correct diagnosis out of thirteen cases. The symptoms vary according to the type of Meckel's diverticulum, obstructive, inflammatory or the peptic ulcer type, and are not typical or characteristic. Therefore, the differential diagnosis is difficult. In the differential diagnosis the following pathological conditions should be considered: (1) Acute appendicitis, (2) cholelithiasis, (3) intussusception in young children, (4) diverticulitis of the large bowel, especially sigmoid colon, (5) involvement of appendices epiploicae with torsion and inflammation, (6) acute salpin-

gitis, (7) primary pneumococcic peritonitis, (8) Littre's hernia with obstruction, (9) perforation of ileum (due to foreign bodies) and (10) torsion or strangulation of small bowel with obstruction.

Symptoms of the inflammatory and obstructive type resemble, more or less, those of an inflamed abdominal viscus or a perforative lesion with early partial obstruction.

The onset is usually sudden, pain is early, of colicky character and severe and is localized at first around the umbilicus. Nausea and persistent vomiting are present. Early abdominal distention develops. Tenderness and rigidity is localized in the right or left lower quadrant of the abdomen below the umbilicus.

Halstead describes the shape of the abdomen as an "inverted cone" which he thinks is due to obstruction of the upper part of the intestinal tract. During the early attack the absence of distention of the flanks is conspicuous. The temperature is higher than in appendicitis and toxemia is also more pronounced. A partial or complete obstruction may develop. The most difficult differential diagnosis is probably the one from appendicitis.

Rarely will inflammation develop in a normal Meckel's diverticulum. As a rule there is some predisposing factor present. Meckel's type of diverticulum communicates with the intestine through a rather wide opening. The contents are liquid and the complete muscular coat enables the diverticulum to empty simultaneously with the ileum. This is the main reason why inflammation of Meckel's diverticulum is not as frequent as that of the appendix. It is also, therefore, difficult to visualize Meckel's diverticulum by x-ray. Inflammation of Meckel's diverticulum varies from the mild catarrhal to the gangrenous inflammatory type with perforation and peritonitis. The inflammation may be specific, due to tuberculosis or typhoid, or non-specific caused by trauma, parasites, foreign bodies or idiopathy. Borgreve reports foreign bodies in Meckel's diverticulum. Ascaris were seen by Lohr causing spastic ileus.

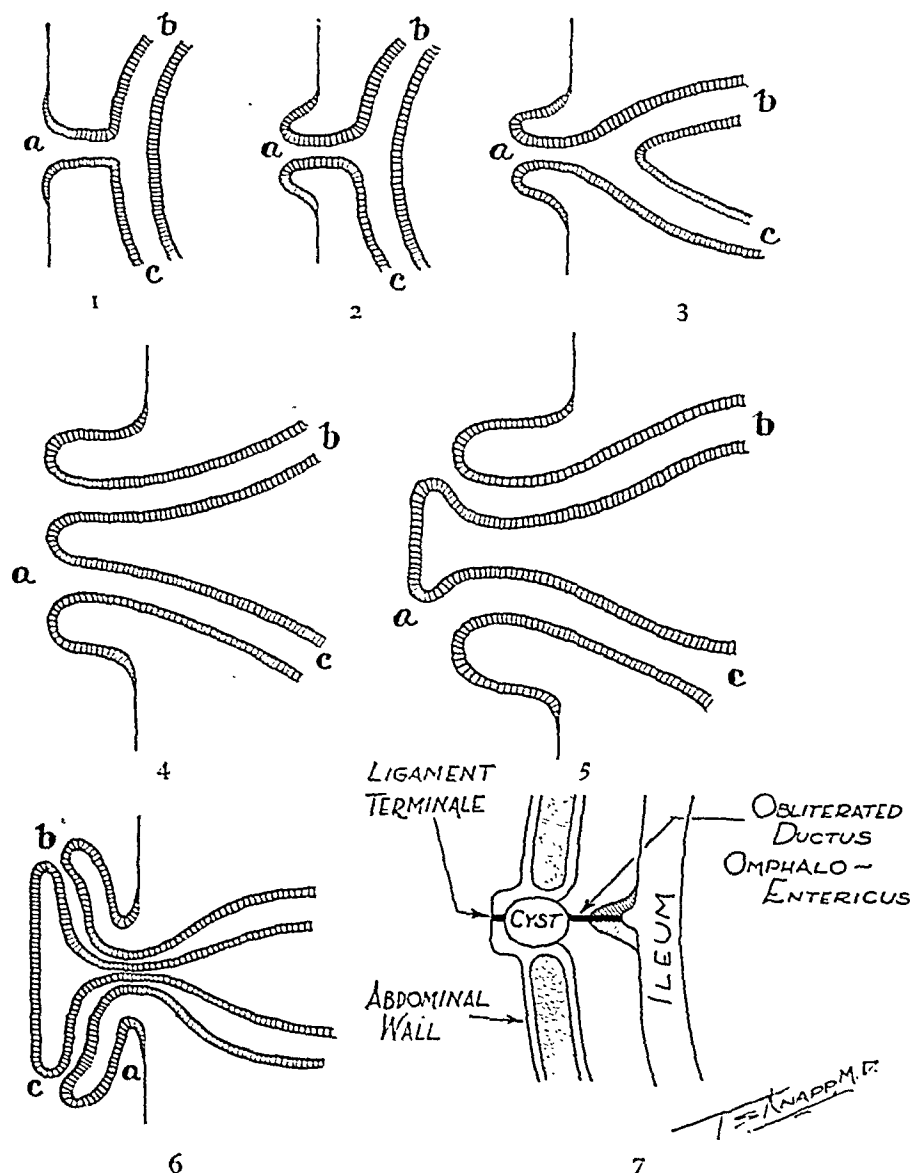


FIG. 1. Scheme of the fistula of the ductus omphalo-entericus and its sequences according to Barth. 1, Scheme of the simple and open Meckel's diverticulum; a, originating from the small intestine; b, open through the umbilicus to the outside. 2, Onset of the eversion of the diverticulum. 3, Progressive eversion of the diverticulum. The opening is now in the umbilicus. Angular deviation of the afferent and efferent loops of bowel with beginning spur formation. 4, Complete eversion of the diverticulum with accentuated angulation of the loop of bowel and protrusion of the spur. 5, Mushroom type prolapse of the bowel. Afferent and efferent loops ending with separate openings. 6, Similar condition as in 5, however, in progressive stage. 7, Scheme of an umbilical ductus omphalo-entericus cyst.

#### HETEROTOPIC TISSUE AND ULCER FORMATION

Schaetz revolutionized with his serial studies of thirty diverticula, the entire conception of the histological structure of Meckel's diverticulum. In only 57 per cent the entire mucosa was similar to that of the ileum. Pancreatic tissue and gastric mucosa was shown by 16.6 per cent. One case showed pancreatic tissue; one carci-

noid mucosa and one mucosa of undeterminable heteroplasia. Mucosa characteristic of colon was reported by Hudson, Koplic and Stern. Heterotopic tissue occurs in about 25 per cent of cases of Meckel's diverticulum, according to Matt and Fimpone. Farr and Penke try to explain that the heterotopic tissue is a remnant from a primary digestive system during the early weeks of fetal life. Pierre Masson proposes



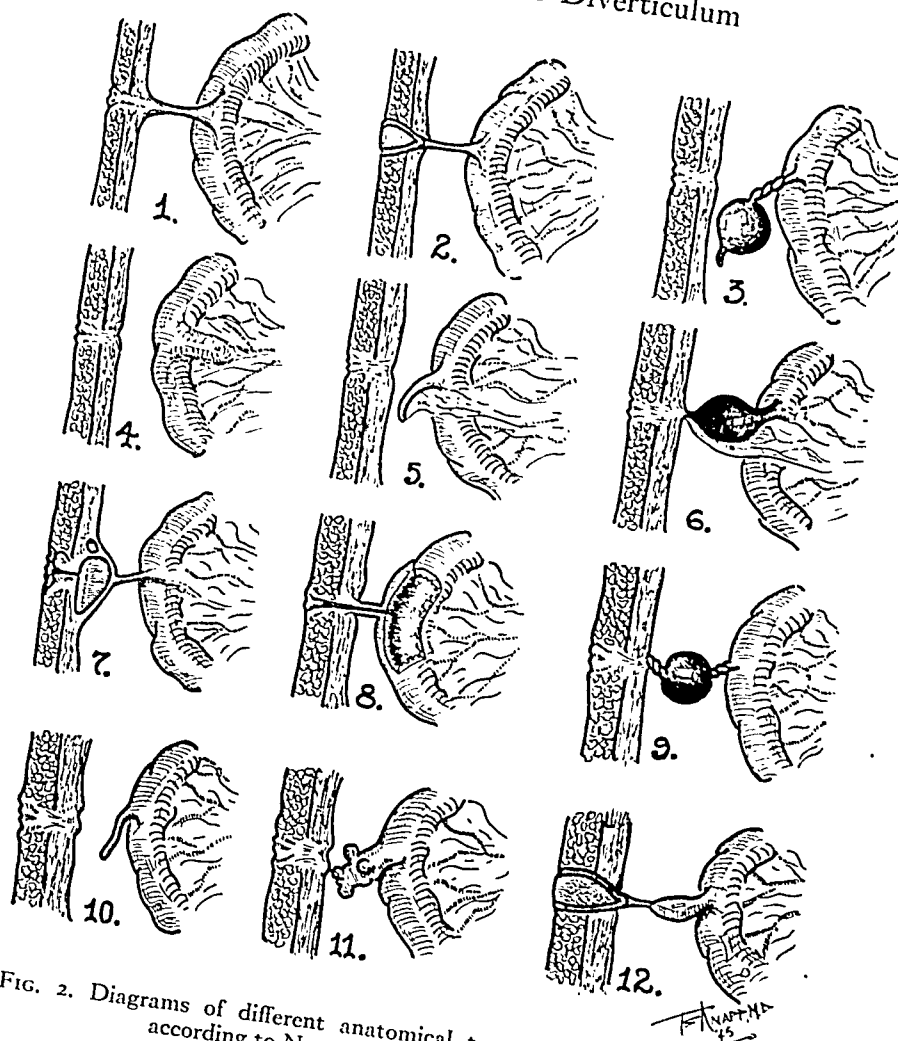


FIG. 2. Diagrams of different anatomical types of Meckel's diverticuli according to Nygaard, Walters and Callender.

his dysembryoma theory and Schaetz his implantation theory.

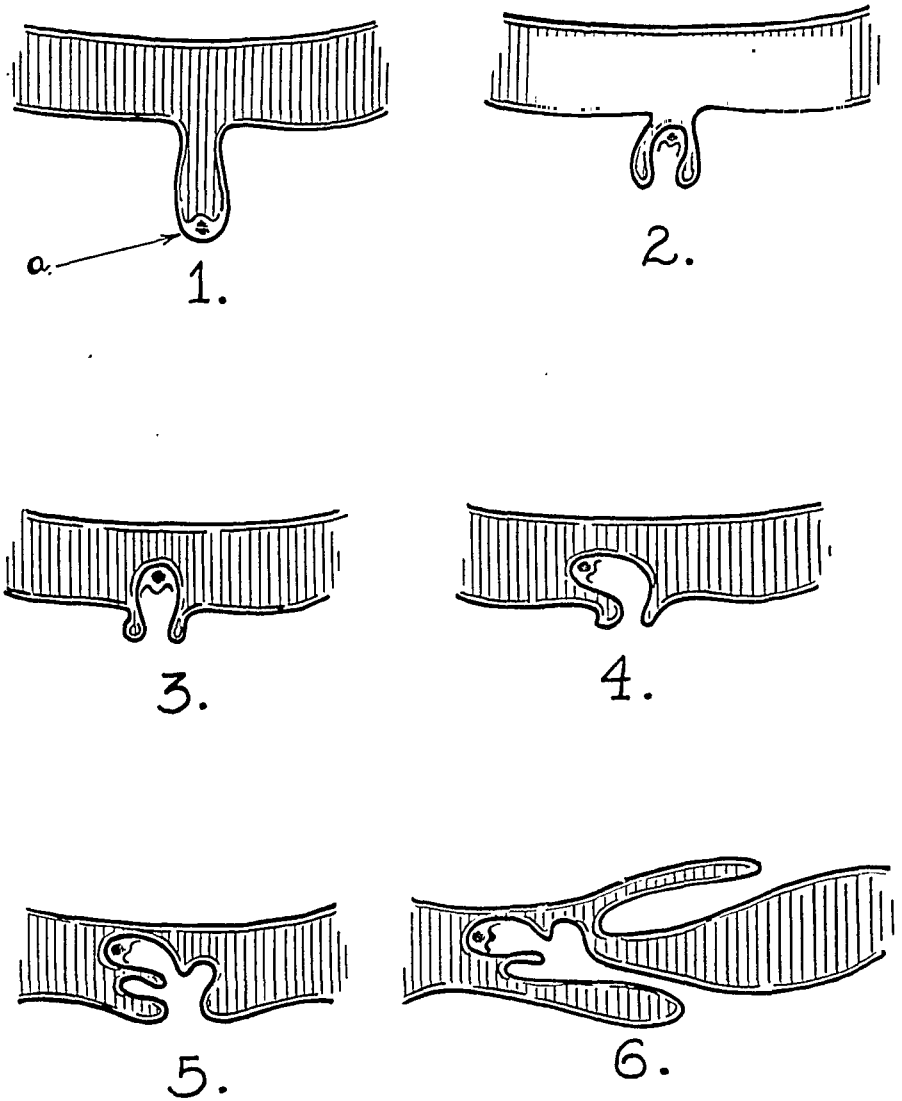
There are quite a few theories about the development of heterotopic tissue. According to Fishe and Albrecht, the primitive entoderm possesses the ability to develop in any of the types of epithelium or glands from the digestive tract. If stimulated locally it will develop into a tissue anomalous for a particular region.

The gastric mucosa, found occasionally in Meckel's diverticulum, is probably displaced tissue in the vitelline duct. Zenker, in 1861, was the first who recognized that gastric heterotopic mucosa in Meckel's diverticulum is much more common than pancreatic heterotopia. Kaufman found an accessory pancreas the size of a pea in a

three-year old girl. The earliest observation of aberrant gastric mucosa was reported by Tillmann in 1881, found in an umbilical polyp.

Both types of heterotopia may be common in one diverticulum. Gastric heterotopic mucosa may be present in about 15 to 20 per cent (Greenblatt, Rand, Chaney). Similar statistics are collected by Miller and Wallace ninety-three cases, Mason and Graham thirty-three cases, Johnston and Renner seventy-eight cases.

Different types of tumors or tumor tissues may occur occasionally in Meckel's diverticulum. There are only very few cases reported of carcinoid or argentaffin tumors, similar to those found in the appendix (Stewart, Taylor and Price).



WAPPMP

FIG. 3. Diagram showing the probable course of development of the intussusception due to inversion of Meckel's diverticulum according to Edwards.

Brown describes medullary carcinoma, Michael adenocarcinoma in a man of sixty-seven years, Nygaard mentions leiomyoma and sarcoma in a sixty-two-year old patient. A spindle celled sarcoma in a sixty-year old man was found by Liccione. Starling describes a very unusual case of a simple polyp causing melaena in a boy thirteen years of age, who had his first attack at the age of three.

Isles of heterotopic gastric mucosa, as stated previously, may occur in Meckel's diverticulum or even line the entire diverticulum and predispose for ulcer formation. The ulcer is usually situated at the area

where the gastric mucosa ends and the normal intestinal mucosa begins. This resembles very closely the marginal jejunal ulcer following gastroenterostomy. Ashner and Karlitz reviews the literature on this subject and reports thirty-three cases of proven or probable peptic ulcer of Meckel's diverticulum. Other cases reported (Etzchegorry, Flure, Patel, Lepart and Cobb) prove that the gastric mucosa could always be demonstrated at the site of the ulcer.

The etiology is not definitely established. Some believe (Greenwald, Steiner, Kaufman and Schaetz) it is the presence of gastric mucosa, with its secretion of hydro-

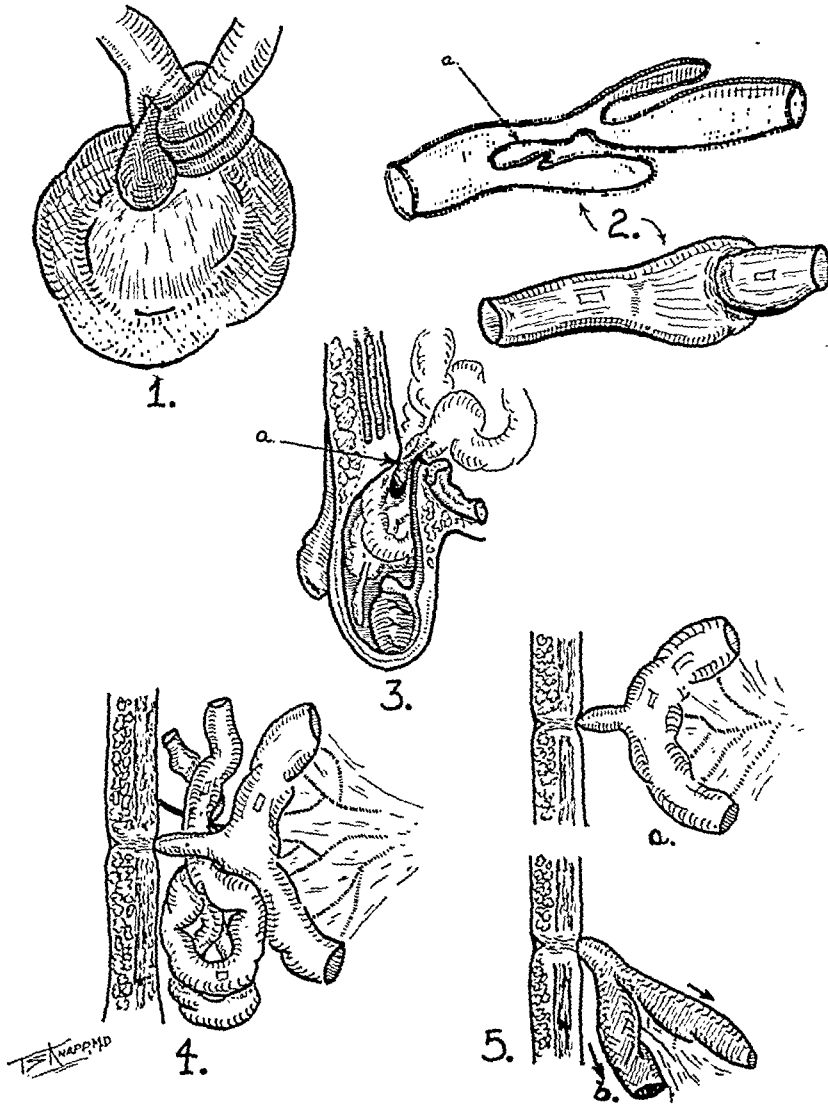


FIG. 4. Diagrams showing different types of intestinal obstruction caused by Meckel's diverticulum. 1, Strangulation of small bowel by double knotting of Meckel's diverticulum. 2, Intussusception of small bowel due to inversion of Meckel's diverticulum; a, Meckel's diverticulum. 3, Strangulation of Meckel's diverticulum in a congenital inguinal hernia; a, Meckel's diverticulum. 4, Strangulation of loops of small bowel due to a trap-like action of a Meckel's diverticulum adherent to the inner side of the umbilicus and persistent omphalo-mesenteric vessels. 5, Intermittent obstruction due to a Meckel's diverticulum adherent to the umbilicus; a, not obstructed; b, obstructed.

chloric acid and pepsin which predisposes to ulcer. Winkelbauer states that the causative factor is probably spasm of the diverticulum.

Intestinal hemorrhage of unexplained origin or abdominal pain of intense character might make one suspect, among other things, Meckel's diverticulum. Intestinal hemorrhage, due to peptic ulcer of Meckel's

diverticulum, is a clinical entity in the disease of infancy. The complications of peptic ulcer of Meckel's diverticulum are the same as of any other peptic ulcer, bleeding and perforation. Schaetz, in his series, reports that the most frequent complication is that of hemorrhage which amounted to 81 per cent in his cases. The next frequent complication is perforation

in 56 per cent in his series of thirty cases.

The symptoms are either obscure or more or less those of a peptic ulcer. The hemorrhage originates usually from a peptic ulcer in the mucosa close to aberrant gastric mucosa at the neck of the diverticulum. The ulcer is not in the gastric mucosa itself.

### OBSTRUCTION

The most common pathological changes resulting from Meckel's diverticulum are of the obstructive type. Mumford states that 6 per cent of all cases of obstruction are due to Meckel's diverticulum. Meckel's diverticulum, with partial obliteration and the formation of bands, is one of the most common causes of obstruction. Probably the first case of intestinal obstruction, due to Meckel's diverticulum and persistent omphalomesenteric vessels, was recorded by Van Doeveren and described by Sandifort in 1793.

The classification of the mechanics of intestinal obstruction as given by Ochsner:

- I. With free unattached diverticulum
  - (a) Knot tied around gut
  - (b) Dragging and kinking of loop of intestine by distended or cystic diverticula
  - (c) Twisting of bowel at origin of diverticulum
  - (d) Chronic inflammation of diverticulum and intestine with narrowing of ileum
  - (e) Acute diverticulitis
- II. Diverticulum attached to the abdominal wall or abdominal viscus
  - (a) Band constricting or interfering with blood supply
  - (b) Volvulus of loop of intestine passing under diverticulum and becoming twisted
  - (c) Volvulus of intestine attached to diverticulum with point of attachment as fixed point of rotation
  - (e) Acute diverticulitis
  - (f) Prolapse of intestine through an umbilical fistula.



FIG. 5. Photograph showing gangrenous small bowel due to obstruction caused by double knotting of a Meckel's diverticulum; probe in Meckel's diverticulum.

Following peritonitis, Meckel's diverticulum may become adherent to the peritoneum and intestine and may prepare the way for possible obstruction. A pull or twist of the intestine by Meckel's diverticulum is a rather rare form of obstruction. The free Meckel's diverticulum may form a knot, or even a double knot, around the small intestine and mesentery.

Strangulation of the intestine by Meckel's diverticulum or its band formations, kink formations of the bowel by contracting bands, and adhesions are the more common types of disturbance. The diverticulum may strangulate itself by excessive rotation with resulting gangrene. Following intestinal ileus, eversion of part of the intestine into the diverticulum or invagination of the diverticulum into the intestine may occur. It is often found that invagination of Meckel's diverticulum is associated with invagination into the small bowel. Occasionally, however, invagination is found without involvement of the ileum. Tumors found in the invaginated Meckel's diverticulum, as lipoma, cylindroma, fibroadenoma, accessory pancreatic tissue, make us believe that they probably have something to do with the invagination mechanism. The exciting factor in most cases of intussusception, however, is usually a nodule of pancreatic tissue situated near the fundus of the diverticulum. Lower reports that only fifty-two cases of intussus-

ception due to inverted Meckel's diverticulum have been mentioned in the literature. Hertzler, Gibson, Fauntleroy, Depish, Greenwood, Johnson, Hood, Vickers and Stone are among the authors reporting this type of intussusception.

Meckel's diverticulum occurs rarely in connection with hernia. Pabst reviewed 123 cases of this type and found sixty-six in inguinal, twenty-four in crural and eighteen in umbilical hernias. In fifty-four cases incarceration was present. Even rarer than the above mentioned types is the incarceration of a Meckel's diverticulum in connection with femoral hernia. Sweet reports such a case. In a review of literature from 1700 to 1929, he found listed only fourteen cases of incarcerated Meckel's diverticulum in femoral hernia. Brown tries to explain the etiology for the occurrence of Meckel's diverticulum in hernias by the fact that the mesentery at its origin is probably too short and, therefore, the small bowel located nearer to the different hernial openings.

The clinical symptoms of obstruction are the same as those of any other ordinary bowel obstruction, therefore, correct preoperative diagnosis is difficult, too.

#### PROGNOSIS AND MORTALITY

Prognosis and mortality vary with the severity of the condition and the time of operation from 7.6 per cent to 58 per cent. Early operation is followed by relatively low mortality (7.6 per cent), however, operation after perforation tremendously increases the mortality (58 per cent) (Greenwald).

Schaetz in his series reports a mortality of 38 per cent following perforated ulcer in Meckel's diverticula. Goodman reports a mortality of 9.3 per cent, Everhart 57 per cent, Hudson in his statistics shows a mortality of 22.2 per cent, others a mortality of 37.5 per cent.

#### ANALYSIS

Our analytical study is based on twenty-three patients with Meckel's diverticulum

operated upon in the Charleston General Hospital by different members of our surgical staff in the years 1938 to May, 1945 inclusive. In this series, the preoperative diagnosis was correct only in one case and was taken into consideration as a second diagnosis in an additional case. The other findings were incidental to operation and exploration. In fourteen cases Meckel's diverticulum was without pathological change and apparently did not cause symptoms. In two cases the diverticulum showed only slight signs of inflammation. All cases in this series having accentuated symptoms were apparently due to obstruction, directly or indirectly caused by the anatomical variations of Meckel's diverticulum and its persistent omphalomesenteric vessels.

We conform, in our analysis, with the statements made by several other authors mentioned in the first part of this paper, that bowel obstruction is undoubtedly the most dominant disorder initiated by Meckel's diverticulum. Two Meckel's diverticula were incarcerated in inguinal hernias, one in a seven-months old infant and one in a fifty-three-year old man. An obstruction caused by double knotting of a free Meckel's diverticulum around a segment of bowel and its mesentery and one case in which a loop of small bowel became trapped between a Meckel's diverticulum adherent to the umbilicus and the persistent omphalomesenteric vessels, are probably the most interesting cases in our series.

Histological findings showed different types of heterotopia (gastric mucosa, duodenal mucosa, pancreatic tissue) but no ulcer formation. One patient died, probably because of extensive bowel damage and rather late surgical intervention.

The sex incidence, with a  $2\frac{1}{2}$  per cent greater frequency in male than in female, corresponds to the reports noted by the majority of the authors. The youngest patient was seven months and the oldest seventy-seven years old, with an average age of  $31\frac{1}{2}$  years. All our patients were of the caucasian race. We did not find any

comment in the literature on the relationship of race to Meckel's diverticulum.

#### CASE REPORTS

CASE I. A—63130, R. S., a forty-one year old white male, was admitted to Charleston General Hospital on June 28, 1944, with the complaint of severe pain in the abdomen. He stated that he was in good health until the morning of the day of admission, at which time he was struck with a sudden pain in the epigastric region, which was so severe it caused him to "double up." The pain continued, became more severe at times and was of a cramping nature. There was pain in the epigastrium and in both lower quadrants, more pronounced on the right. He had one voluntary bowel movement the morning before the pain began. After the onset of pain he took some magnesium sulfate and three enemas, without results. He gave a history of frequent attacks of indigestion during the past three or four years, characterized by burning in the epigastrium one-half to one hour after meals. He stated that he is relieved by taking soda. His past history and family history were non-contributory.

Physical examination revealed the patient to be in acute abdominal distress. His temperature was 102.2°F., blood pressure 117/108, pulse 80 and respirations 20. There was marked tenderness and rebound tenderness in the epigastrium, to the right of the umbilicus and in both lower quadrants, however, more pronounced on the right. The abdomen was slightly distended. Rectal examination was negative.

The clinical laboratory findings were essentially negative except for a leukocytosis of 15,600 and neutrophils, segment 90 per cent. A scout plate of the abdomen was taken which did not show free air or any definite evidence of obstruction.

The impression, at the time of examination, was possible early obstruction; and that a subacute perforation of peptic ulcer should be excluded.

After routine preparation the patient was taken to the operating room and, under spinal anaesthesia, the abdominal cavity was entered through a right paraumbilical incision. Upon exploration of the abdominal cavity some free serous fluid was encountered. A Meckel's

diverticulum about 10 cm. long was found to be adherent to the inner side of the umbilicus; the diverticulum originated from the antimesenteric portion of the ileum about two feet from the ileocecal junction. The proximal two-thirds of the ileum was distended and showed signs of beginning peritonitis. These findings were due to an obstruction, probably intermittent in character, caused by the pull of the intestine on the adherent Meckel's diverticulum. Relaxation of the intestinal pull released the obstruction. The diverticulum was resected in the routine manner and appendectomy done. The patient made an uneventful recovery and was discharged on July 5, 1944. This patient's ulcer symptoms for the last few years were probably caused by the diverticulum.

CASE II. A—56289, K. B., a white man, twenty-three-years old was admitted to Charleston General Hospital on October 28, 1943, complaining of acute abdominal pain. He stated that he noticed several sharp pains about eighteen hours before admission. These pains were of crampy character and lasted from three or four minutes to as long as about an hour. He could not sleep well and was awakened a few hours later by a nightmare. This was followed in a few minutes by a rather sudden onset of acute generalized abdominal pain. Associated with the pain was nausea and vomiting. There was no hematemesis, no bowel movements and no history of previous attacks. His previous history and family history were non-contributory.

Physical examination revealed a twenty-three-year old white man, well nourished and developed, in acute abdominal distress. His blood pressure was 136/90 and temperature 98°F. There was very marked generalized abdominal tenderness and rebound tenderness, more pronounced in the left lower quadrant. Rigidity was present over most of the abdomen.

Clinical laboratory findings were: Urine: traces of albumen, 92 per cent hemoglobin, 4,800,000 erythrocytes, 21,000 leukocytes, 14 per cent lymphocytes, 3 per cent monocytes, neutrophils, stab 2 per cent and neutrophils segment 81 per cent.

A diagnosis of (1) intestinal obstruction and (2) diverticulitis was made. Exploration was under cyclopropane and ether anesthesia. A hard mass was encountered in the pelvis which, on further examination revealed an intussusception. Upon reducing the intussusception a

large gangrenous Meckel's diverticulum was found, which had become inverted into the lumen of the ileum and had been carried by peristaltic waves approximately 10 inches down into the small intestine. The diverticulum was resected in the routine manner and routine appendectomy was done.

Pathological report: (1) Intussusception of Meckel's diverticulum with a small area of mucosa and acute hemorrhagic necrosis; (2) appendix with remnants of old adhesions.

The patient made an uneventful recovery and was discharged on November 4, 1943.

CASE III. A—61893, W. B., a fifty-four-year old white male was admitted to the Surgical Department of Charleston General Hospital on January 9, 1938, with the complaint of generalized acute abdominal pain. The day before admission this patient was taken with severe cramping and griping pain in the lower abdomen. Associated with pain was nausea and vomiting. He had not had any bowel movements since January 7th. Several enemas had been given but were not effectual. The patient stated he had had previous attacks of slight cramping lower abdominal pain, the last of which was about one year before. None were as severe as the present one. Family and previous histories were non-contributory.

Physical examination revealed: blood pressure 128/82, pulse 110, respirations 25 and temperature 99.6°F. The patient was somewhat undernourished, in acute distress and complaining of severe cramping pain over the entire abdomen. The abdomen was distended and rigid. There was marked tenderness and rebound tenderness over the entire abdomen. There was a tympanitic note on percussion.

Clinical laboratory findings: Urine; albumin +1, occasional red blood cells. Blood count: Leukocytes 18,600, lymphocytes 6 per cent, monocytes 2 per cent and neutrophils 92 per cent. The Kline exclusion was 3 and Kolmer Wassermann 4.

X-ray showed a moderate amount of gas throughout the small bowel and colon, with a local area of greater small bowel dilatation just below the umbilicus. This suggested small bowel obstruction, with a local area of strangulation.

Diagnosis: Small bowel obstruction, probably due to volvulus.

After preparation with intravenous fluids the patient was taken to the operating room

(thirty-six hours after onset of symptoms). Under general anesthesia the abdomen was explored through a midright rectus incision. A large amount of bloody fluid was evacuated, after which it was found that a large part of the ileum was completely strangulated by the double knotting of a free Meckel's diverticulum, resulting in gangrene of about three feet of ileum. The entire gangrenous mass was resected and end-to-end anastomosis performed. The patient died on the seventeenth day after a stormy postoperative course.

Pathological Report: The specimen consisted of resected small intestine. The entire loop was about 100 cm. long. The intestine was very markedly distended, its wall blackish red in color and covered with a thin film of fibrin. Similar changes were present on the surface of the mesentery, the veins being markedly congested. Fifteen cm. distal from the place of resection a firm double knot was fixed around the afferent and efferent portions of the intestine, constricting it completely. In this area of constriction a cyst like portion of bowel was present, measuring 7 by 6 by 5 cm. On opening the afferent loop, branching of its lumen into two canals was found to be present. The larger part of the lumen allowed a thin probe to pass into the distended loops. Further examination showed that this was a Meckel's diverticulum which had become knotted around the ileum, its distended distal part forming the cyst like mass described above.

Diagnosis: Complete strangulation of a large part of ileum, due to double knotting of a free Meckel's diverticulum; hemorrhagic necrosis of the strangulated intestine with beginning local peritonitis.

CASE IV. A—63298, M. M., a seven-months old white boy, was admitted to the Surgical Department of Charleston General Hospital on July 4, 1944. Twenty hours prior to admission the patient became acutely ill with fever and diarrhea, with passage of very frequent green, watery stools. This condition became increasingly worse. There was no vomiting. On the morning of admission the patient's mother noticed swelling and redness of the scrotum, the swelling becoming gradually more marked. This patient had always been weak, had been on a formula, carnation milk, with no breast feeding. He had had no childhood diseases. He had had an umbilical hernia since birth and developed generalized impetigo

about two weeks previous and was treated for this condition and showed some improvement.

Physical examination revealed a fairly well nourished, well developed seven-months male child, evidently acutely ill, very fretful when the abdomen was palpated. Temperature was 103°F. rectally, pulse 130. There were scattered dried old pustular skin lesions over the body. The lower abdomen was very tender and moderately distended. There was slight rigidity, more apparent in the right lower quadrant. A hard, tender elongated mass extended down from the area of the right inguinal canal into the scrotum. The entire scrotum was red and edematous, more so on the right side.

Clinical laboratory findings: Urine essentially negative. Blood count: Hemoglobin 59 per cent, erythrocytes 3,400,000, color index 0.86, total number of leukocytes 11,100, lymphocytes 51 per cent, monocytes 2 per cent and neutrophils 47 per cent.

The patient was in a rather poor general condition. A diagnosis of incarcerated right inguinal hernia was made and, after routine preparation, the patient was taken to the operating room.

A transverse incision, anatomical type, was made in the right inguinal region parallel to Poupart's ligament. The aponeurosis of the external oblique was split in the line of its fibers, the sac freed, delivered and opened. Almost the entire cecum, with the appendix and part of the terminal ileum were found in the sac and adjacent cavity. About eight inches from the ileocecal junction a diverticulum about  $\frac{1}{4}$  to  $\frac{1}{2}$  inch long was found on the antimesenteric border of the ileum. Here were signs of hemorrhagic gangrene. This proved to be a true diverticulum containing all layers of the intestinal wall. In view of the patient's poor general condition resection could not be considered. The diverticulum was inverted transversely by two rows of interrupted Lambert sutures. The contents of the sac were replaced into the abdominal cavity, the sac ligated and hernia was repaired according to the Ferguson technic.

The postoperative course was rather uneventful except for the first postoperative day when his temperature went up to 105°F. rectally. He was discharged on June 14, 1944, in good general condition.

CASE V. A—44641, R. B. a thirteen-year old white boy, was admitted to Charleston

General Hospital on January 4, 1943, complaining of severe abdominal pain. This patient began to have generalized abdominal pain of cramping and burning character about two hours after his dinner. Shortly thereafter he started to vomit and continued to vomit numerous times. The pain continued to increase in severity, remaining generalized and cramping. There was no fecal vomiting and no chills. He had had no previous similar attacks. His past history was non-contributory. The patient had had the usual childhood diseases. His appetite previously was good and bowel movements normal.

Physical examination revealed a thirteen-year old boy in apparent acute distress, complaining of periodic abdominal pains. His temperature was 97°F. rectally, pulse 100 and respirations 24. The abdomen, especially the lower part, was distended and tender, more marked over the right lower quadrant and about the region of the umbilicus. There was rebound tenderness and muscle guarding over the same area. A tender, ill defined mass was found about 1 inch to the right and below the umbilicus. No other masses could be found. Peristalsis was active and not synchronous with pains. Rectal examination was negative.

Clinical laboratory findings: Urine essentially negative, hemoglobin 85 per cent, erythrocytes 4,600,000, leukocytes 30,000, lymphocytes 9 per cent, monocytes 4 per cent and neutrophils; stab 2 per cent and neutrophils segment 85 per cent.

A preoperative diagnosis of possible acute appendicitis was made, acute intestinal obstruction to be excluded.

After preparation with intravenous fluids, the patient was taken to the operating room and, under general anesthesia, exploration of the abdomen by way of a McBurney incision was performed. Two loops of the lower ileum were markedly discolored, almost black. A Meckel's diverticulum about 10 cm. long and 3 cm. wide, having about the same size and appearance as the ileum, was found about one foot from the ileocecal junction and extended to the undersurface of the umbilicus. About 2 inches from the umbilical attachment of the Meckel's diverticulum two string-like structures originated and extended to the ileum where they inserted into each side of the diverticulum 2 to 3 inches apart. In these compartments loops of incarcerated dark bowel



were caught. At the umbilical attachment of Meckel's diverticulum a peritoneal defect about 1 inch in diameter was found, exposing bare muscle. The string-like cords were resected, the diverticulum resected in the usual manner and the peritoneal defect repaired. The bowel was watched. Its normal color returned within twenty minutes. Routine appendectomy was done.

Postoperative Diagnosis: bowel obstruction due to Meckel's diverticulum adherent to the umbilicus by reason of persistent obliterated omphalomesenteric vessels.

This patient had a rather stormy postoperative course and developed signs of small bowel obstruction. On January 17, 1943, a secondary operation was undertaken. Ileocolostomy and cecostomy for relief of the bowel obstruction were performed. After a rather prolonged convalescence the patient left the hospital in good general condition on February 12, 1943.

#### COMMENT, SUMMARY AND CONCLUSIONS

A review of the embryological, anatomical and pathological factors of the Meckel's diverticulum was given with its relations to symptomatology, diagnosis and therapy. Twenty-two cases were analyzed and five cases of small bowel obstruction due to different types of Meckel's diverticulum are described in detail.

These cases are presented because of the interesting and rather unusual pathology they offer, also to stress again the point that to make a correct preoperative diagnosis of Meckel's diverticulum is difficult and, therefore, in any case of small bowel obstruction without apparent cause Meckel's diverticulum as an etiological factor should be considered.

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# ULTRAVIOLET BLOOD IRRADIATION THERAPY\*

## FURTHER STUDIES IN ACUTE INFECTIONS

GEORGE MILEY, M.D. AND JENS A. CHRISTENSEN, M.D.

PHILADELPHIA, PENNSYLVANIA

IN the study of 445 consecutive and unselected cases of acute pyogenic infections and seventy-four cases of virus or virus-like infections we have found that our original observations<sup>1,2</sup> have been definitely confirmed and that not only sulf-resistant infections have responded to this therapy but a high percentage of penicillin-resistant infections have also responded quite favorably.

In addition, we have observed that toxemias due to various virus or virus-like infections subside rapidly and in the same manner as those secondary to acute pyogenic infections,<sup>3,4</sup> an extremely important clinical advantage in dealing with a rapidly fulminating and overwhelming infection, the etiological agent of which is frequently discovered or suspected only after death has occurred.

### TABULAR REPORT

The following tabular report including a wide variety of acute pyogenic infections is as follows:

RESULTS IN 445 CASES OF ACUTE PYOGENIC INFECTION  
GIVEN ULTRAVIOLET BLOOD IRRADIATION THERAPY  
AT THE HAHNEMANN HOSPITAL, PHILADELPHIA,  
OVER A PERIOD OF SIX AND ONE-HALF YEARS

	No. of Cases	Recov- ered	Died
Early			
Puerperal sepsis.....	3	3	
Incomplete septic abortion...	12	12	
Acute furunculosis and car- bunculosiis.....	15	15	
Abscesses.....	2	2	
Acute Strep. hemolytic oro- pharyngitis.....	5	5	
Acute tracheobronchitis.....	12	12	
Acute wound infections.....	2	2	
Acute pansinusitis.....	1	1	
Acute pyelitis.....	1	1	
Acute otitis media.....	2	2	
Fever of unknown origin.....	1	1	
Moderately advanced			
Puerperal sepsis.....	14	14	
Incomplete septic abortion...	57	57	

	No. of Cases	Recov- ered	Died
Acute furunculosis and car- bunculosiis.....	21	21	
Abscesses.....	13	13	
Acute Strep. hemolytic oro- pharyngitis.....	5	5	
Endometritis and parametritis	17	17	
Acute wound infections.....	6	6	
Salpingitis.....	15	15	
Peritonitis.....	18	16	2
Osteomyelitis.....	26	25	1
Fever of unknown origin.....	13	13	
Lobar and bronchopneumonia	11	11	
Atypical (virus) pneumonia...	10	10	
Preoperative.....	13	13	
Postoperative.....	44	41	3
Non-healing wounds.....	6	6	
Thrombophlebitis.....	34	34	
Apparently moribund			
Puerperal sepsis.....	4	3	1
Incomplete septic abortion...	2	1	1
Generalized peritonitis.....	4	2	2
Abscesses: Pelvic.....	6	5	1
Rectal.....	2	1	1
Scrotum.....	1	1	
Wound infections.....	3	2	1
Fever of unknown origin.....	2	1	1
Lobar and bronchopneumonia	2	1	1
Tb. meningitis.....	3	..	3
Mesenteric thrombosis, dia- betes mellitus.....	1	..	1
Septicemias:			
Staph. aureus—albus with sulfa drugs.....	7	..	7
without sulfa drugs.....	9	9	
Str. hemolyticus.....	3	3	
Str. non-hemolyticus.....	2	1	1
Str. viridans—subacute bac- terial endocarditis.....	13	..	13
Str. hemolyticus endocar- ditis.....	1	..	1
Str. non-hemolyticus endo- carditis.....	1	..	1

Summary	Early	Moder- ately Ad- vanced	Appar- ently Mori- bund
Number of cases.....	56	323	66
Number recovered.....	56	317	30
Percentage recovered.....	100%	98%	45%

\* From the Blood Irradiation Clinic of the Hahnemann Medical College and Hospital of Philadelphia, Pa.

RESULTS IN 74 CASES OF VIRUS OR VIRUS-LIKE INFECTIONS

	No. of Cases	Recovered	Died
Early			
Primary atypical or "virus" pneumonia.....	2	2	
Poliomyelitis			
Bulbo spinal type.....	0	0	
Spinal type.....	36	36	
Moderately advanced			
Primary atypical or "virus" pneumonia.....	11	11	
Poliomyelitis (non-toxic)			
Bulbo spinal type.....	4	4	
Spinal type.....	11	11	
Mumps.....	1	1	
Apparently moribund			
Primary atypical or "virus" pneumonia.....	2	2	
Poliomyelitis			
Bulbo spinal type.....	7	6	1

The poliomyelitis patients were consecutively treated in an epidemic in which the mortality of the untreated acute bulbar cases exceeded 40 per cent, as opposed to that of 9 per cent in the cases above.

CASE REPORTS

CASE I. No. 79317½. S. H. A female, aged fifty-four, was admitted to Hahnemann Hospital, Philadelphia, Pennsylvania on July 5, 1942. She was not acutely ill before being admitted but was complaining of a severe pain in the right side and a full burning sensation in the rectum. Her temperature was 103°F., with no vomiting and no nausea. Laboratory data were as follows: hemoglobin 13.8, red blood count 4,360,000, white blood count 10,000, polymorphonuclears 80 per cent and lymphocytes 20 per cent. Respiration was 20, pulse 110 and blood pressure 110/66.

Abdominal examination revealed marked tenderness in the right and left lower quadrant, but no gallbladder tenderness and no costo-vertebral tenderness. Rectal examination revealed tenderness and a possible mass near the rectal-sigmoid junction.

Given sulfathiazole, 15 grains every four hours, her condition improved, but on her eleventh hospital day her temperature began to rise again with chills, the rises being of a characteristic spiking nature. Blood cultures, however, were negative as was the Widal.

The red blood count deteriorated to 1,970,000, white blood count to 7,300 and hemo-

globin to 6.8. Frequent blood transfusions were necessary. X-ray showed either an acute diverticulitis or a walled off pocket in connection with the sigmoidal lumen.

On August 3, 1942, her temperature rose to 104.2°F. The patient was sigmoidoscoped and a large amount of pus drained from an abscess at the rectosigmoid junction. In spite of this the patient's temperature did not subside, and when seen on August 6th, was apparently moribund with Cheyne-Stokes respiration, showing a rapidly falling blood count, a temperature of 104°F, increasing toxemia and a rapid spread of the infection. The patient was semi-comatose, anuric, edematous and in early shock. Her extremely toxic condition was believed to be due to two factors: (1) overwhelming toxemia of bacterial infection, (2) the toxic effects of sulfathiazole, which failed to control infection.

Ultraviolet blood irradiation therapy with 200 cc. of citrated blood was given, and sulfa drugs were stopped; the patient's condition improved with supportive fluids and blood transfusions during the next forty-eight hours. Her temperature dropped to a level of 101°F to 102°F. The toxic condition subsided slightly and the patient was more rational, taking some food and voiding normally for the first time in more than a week.

On August 10, 1942 a second ultraviolet blood irradiation with 275 cc. of citrated blood was given after which the patient's temperature receded to nearly normal with a marked improvement in her general condition. The white count rose to 11,700 from the pre-irradiation value of 6,000. The patient now had normal bowel movements, ate well and regained strength. Rectal examination produced no more pus, but a mass in the sigmoid could still be felt.

On August 19th, the patient's temperature, pulse and respiration rose to 102°F, 130, 38 respectively and her condition deteriorated somewhat. The white blood count was 9,600.

Another ultraviolet blood irradiation of 275 cc. of citrated blood was given to which the patient responded in forty-eight hours with a normal temperature, a subsidence of toxic symptoms, lowered pulse and respiratory rate to 100 and 20 respectively.

The diagnosis was para-rectal abscess, and perforation of sigmoid diverticulum with abscess formation, rapid spread of infection.

The patient made an uneventful recovery and was discharged two weeks later on September 2, 1942, in apparently good condition.

CASE II. No. 83812. V. P. A female patient, aged fifty-nine, was admitted to the McKinley Hospital, Trenton, New Jersey, on July 18, 1944, suffering from an acute cholecystitis with a temperature of 102°F.

A cholecystectomy was planned after her acute symptoms had subsided. She was, therefore, immediately put on sulfathiazole 15 grains every four hours and 20,000 units of penicillin every four hours day and night. The sulfa drug level was kept between 2 mg. per cent to 6 mg. per cent for two weeks. On the second day an additional 30,000 units of penicillin were given by vein. This therapy was supported by blood transfusions of 250 cc. on the fifth, sixth, seventh and eighth hospital days.

In spite of this intensive therapy the patient's condition became increasingly critical and her temperature curve was definitely of a septic nature. Blood cultures were negative, urine was negative, blood chemistry normal, red count 4,350,000, white count 10,050 and hemoglobin 93 per cent. All agglutination tests were negative and Wassermann was negative.

On the twelfth day another 100,000 units of penicillin were given intravenously with a 500 cc. blood transfusion, as a rectal hemorrhage had occurred the day before.

On the fourteenth day the patient was considered hopelessly moribund by her attending physicians. She was semi-comatose, irrational and anuric. Her body was covered with a macular rash and there was noted an extensive edema of the eyes, face and ankles. At 6 P.M. of that day ultraviolet blood irradiation therapy, (250 cc. of citrated blood), was given and sulfa drugs stopped. The patient's temperature was 106°F. at this time. At 10 P.M. her temperature rose to 108°F. with chills. One-half hour later, however, her temperature began to drop, as profuse sweating appeared. Urine was passed for the first time in forty-eight hours. The following morning the patient became rational again. About eighteen hours after ultraviolet blood irradiation therapy her temperature dropped to 97°F., rising that evening to 101°F. In the next four days the patient made a most remarkable recovery; her temperature stayed normal, the rash disappeared, her appetite improved and all

tenderness in the gallbladder region subsided. Normal amounts of urine were voided consistently. Penicillin, 20,000 units every four hours were continued after ultraviolet blood irradiation therapy. In spite of this the patient developed signs of a beginning hypostatic pneumonia of the right lower lobe with temperature up to 102°F., on the sixth and seventh days after ultraviolet blood irradiation therapy. Another application of ultraviolet blood irradiation therapy with 250 cc. citrated blood was given at this time, eight days after the first; the symptoms of pneumonia subsided promptly after forty-eight hours.

The diagnosis was acute fulminating cholecystitis with overwhelming toxemia.

The patient made an uneventful recovery and was discharged on the twenty-ninth day without an operation being considered necessary and to date has shown no signs of cholecystitis.

CASE III. No. 79187. T. N. A male, fifty years of age, was admitted to the McKinley Hospital, Trenton, New Jersey, on May 5, 1943, for treatment of rheumatoid arthritis. He progressed favorably until May 31st, at which time gold thiocyanate was started, but withdrawn as the patient became acutely ill with fever, chills, and temperature of 104°F. Two days previous to this flare-up the patient had a tooth with infected roots extracted, and blood culture taken at this time was positive for *Streptococcus viridans*. He became progressively worse during the following four days despite intensive sulfathiazole therapy.

It was believed by the patient's physician that the prognosis was grave, as the patient had become semi-comatose and irrational. Ultraviolet blood irradiation was recommended as a last resort and was given on June 4, 1943, as soon as sulfathiazole was withdrawn. This was followed by a most dramatic result. The patient's temperature began to fall and in twenty-four hours he was apparently out of danger and at the end of forty-eight hours his temperature was normal and blood cultures were negative. The patient convalesced uneventfully and left the hospital in good condition on June 31, 1943.

The diagnosis was *streptococcus viridans* septicemia.

He has received thirteen blood irradiations since that time, the last one given on April 13, 1946. His rheumatoid arthritis is well con-

trolled and to date there has been no sign of *Streptococcus viridans* present in the blood stream for two years and ten months after his attack of *Streptococcus viridans* septicemia.

CASE IV. No. 851702. R. G., a fourteen-year old male, was admitted to the hospital October 21, 1943, with extensive enlargement of the right parotid area, slight early enlargement of the left parotid and temperature of 102°F. The condition had lasted for twenty-four hours and was diagnosed as mumps.

Ultraviolet blood irradiation therapy using 200 cc. of the patient's blood plus 40 cc. sodium citrate was given October 21st. Slight or mild toxemia was present. On the twenty-second he showed marked improvement twenty-four hours after irradiation. The swelling on the right side was less, and the left side subsided completely. The temperature was 99.0°F. The patient felt better, had a good appetite and ate a full breakfast. On the following day his temperature was 98.6°F, and the swelling on right side was less. The patient was discharged October 30, 1943; all swelling had completely disappeared.

CASE V. No. 21168. R. C. a seventeen year old male, a post-scarlet fever patient was admitted to U.S. Public Health Service Hospital, Sheepshead Bay, New York, on April 9, 1945. He complained of a productive cough for the past two weeks and of pain in the left lower chest on deep breathing during the previous week.

His temperature on admission was 105°F. and his physical examination revealed râles, dullness and diminished breath sounds over the left lower lung.

The following day his temperature dropped to normal and he did not seem ill; x-ray examination showed only a small area of patchy infiltration of the left lower lung field at the cardiophrenic angle. He convalesced uneventfully until on the fourteenth hospital day his temperature began to rise and penicillin was begun. In forty-eight hours his temperature had risen to 105°F. and he was definitely toxic. In another forty-eight hours the patient had become comatose, had renal failure, a blood pressure of 150/90, blood urea nitrogen of 82, blood sugar of 266, carbon dioxide combining power of 34; a diagnosis of acute nephritis was made. On the following day he developed muscular twitching. He came out of the coma but only temporarily. He began to

show evidence of increasing pulmonic complications despite the vigorous use of penicillin, so much so that x-ray examination on May 4th, showed an extensive pneumonia involving the whole lower two-thirds of both lung fields plus a narrow effusion of the right chest, causing 20 per cent compression of the right lung and probable pleuritic reaction of the lower one-third of the left chest. The pneumonic process became increasingly severe for the next four days and since it was apparent from the sputum findings that a penicillin-resistant hemolytic streptococcus was the causative organism, it was believed that the youth was apparently moribund and the prognosis extremely grave. A three-day trial of sulfadiazine had also been ineffective. Due chiefly to its availability, ultraviolet blood irradiation therapy was instituted on May 8th, at which time the patient's temperature was 104.2°F., pulse 120, respiration 36; the patient was semi-comatose and irrational.

The diagnosis was *Streptococcus pneumoniae*, glomerular nephritis and secondary hypertension.

On the first post-irradiation day the patient seemed slightly improved. In forty-eight hours he was less toxic and more rational, though still quite dyspneic. His temperature remained about 101°F. By the fourth post-irradiation day he was definitely improved though still moderately dyspneic and complaining slightly of pleuritic pain. His color had improved.

On May 14th, x-ray examination showed a moderate clearing of the left pleural sac and a diminished pocket in the right. The diagnosis was "resolving bilateral pneumonia." His general condition continued to improve; his temperature had fallen to a level between 98.4°F. and 100.4°F.

Further x-ray examination on May 17th, showed the continued resolution of the bilateral pneumonia with a narrow layer of fluid between the right lung and chest wall and right diaphragm. After May 16th, the patient's temperature failed to rise beyond 99°F., his blood pressure, now normal, also remained normal.

A certain amount of pleuritic reaction remained, and a small amount of fluid could be observed May 24th.

Penicillin, which had been continued empirically and possibly to some extent detrimentally, was finally discontinued May 26 1945.

All dyspnea had disappeared but some tachycardia remained; although on May 29th, there was still some fluid in both lungs, the patient's general condition remained excellent and his lungs finally cleared to the extent that he was discharged in good condition June 27, 1945.

CASE VI. No. 64360. D. G. an eleven-year old boy was admitted to Hahnemann Hospital, Philadelphia, August 8, 1942, with severe cough, chest pain, fever, toxemia and cyanosis. There was a history of cough and fever for six days previous to admission. Physical examination of chest revealed slight impairment of breath sounds over the right scapular area and fine crepitant râles over both apices. Laboratory examination showed a blood count of 4,040,000 red blood cells, 8,400 white blood cells, negative urinalysis and negative agglutination for *Bacillus typhoideus*, *Bacillus paratyphoideus*, A and B, *Bacillus abortus* and *proteus* OX 19. Sputum showed *Micrococcus catarrhalis* in predominance, no pneumococci on culture and the blood smear for *Plasmodium malariae* was negative. Roentgenological examination on August 31st, showed an acute inflammatory process extending into the lung fields from both hilar areas; a second chest x-ray taken September 2nd, showed further invasion by the acute inflammatory process in keeping with a definite deterioration of the child's general clinical condition after two to three days of hospitalization; at this time the red cell count had fallen to 3,460,000, the white count to 5,400.

The diagnosis was primary atypical or "virus" pneumonia with severe toxemia.

Since a virus type of progressing pneumonitis was considered present, and no other therapy was believed effective, ultraviolet blood irradiation therapy was administered.

In twenty-four hours the patient's clinical condition was slightly improved, though x-ray examination revealed little change, if anything a slight progressing of the inflammatory process. The boy's temperature which had been 103.4°F. on the day of irradiation dropped to 100°F.

At the end of forty-eight hours the child's condition had greatly improved, his temperature fell to 98.6°F. for the first time and his severe toxic symptoms had completely subsided; a normal pink color had appeared and his cough seemed less severe. His red cell count

rose to 4,350,000, and his white count to 6,400. From then on he convalesced uneventfully and a roentgenological examination taken September 8th, showed a complete clearing of the lung fields; he left the hospital on that date, six days after a single blood irradiation.

CASE VII. No. 858545. L. T. a twelve-year old boy, when seen had moderate toxemia, some encephalitis manifestations present, temperature 103°F., marked back, bilateral hamstring and gastrocnemius spasm, weakness of both legs, left arm, inability to void and beginning of respiratory difficulty.

Blood Count	Spinal Fluid
White blood cells..... 13,000	Cells..... 180
Polymorphonuclears..... 80%	Pandy.... one plus
Hemoglobin..... 80%	.

The diagnosis was spinal poliomyelitis with progression of muscular weakness.

Ultraviolet blood irradiation therapy was instituted October 31, 1943, using 165 cc. of the patient's blood plus 33 cc. sodium citrate. The following day the patient was about the same, although the tendency to develop encephalitic symptoms has disappeared. His temperature returned to normal November 2nd, the toxic symptoms subsided and no extension of paralysis appeared. By November 3rd, his general condition had greatly improved, with no apparent change in paralytic symptoms. On November 4th ultraviolet blood irradiation therapy, 150 cc. patient's blood plus 33 cc. sodium citrate was again used. His temperature rose to 99.2°F. All acute symptoms then subsided.

CASE VIII. No. 859253. T. H., a twenty-three-year old female, had grave, progressive respiratory paralysis, (complete), toxic with a temperature of 102°F. Both arms and both legs were paralyzed, she was unable to swallow, and was cyanotic even in the respirator. The patient was six months pregnant.

The diagnosis was acute bulbar and spinal poliomyelitis.

Ultraviolet blood irradiation therapy, 180 cc. of the patient's blood plus 36 cc. of sodium citrate was used November 9, 1943. The patient could not be moved from the respirator for any length of time, which necessitated that

the irradiation be given while the patient was in the respirator.

The following day the toxic symptoms were gone and her temperature was 98.6°f. The patient was able to swallow and her color was good. However, complete respiratory failure, and paralysis in both arms and legs were still present.

Thirteen days later color was again poor and definite cyanosis was present. Ultraviolet blood irradiation therapy was repeated, using 180 cc. of the patient's blood plus 36 cc. of sodium citrate. Difficulty in swallowing reappeared. Her color was improved; she rested comfortably apparently, swallowing was made easier, but no change was evident in the paralytic symptoms. By November 30th, the patient was eating well and in general was greatly improved.

While in the respirator a normal male infant was delivered at term, the first such successful delivery of a bulbar poliomyelitis mother in California.

#### CLINICAL OBSERVATIONS

*Treatment of Sulfa Resistant Infections.* The definite limitation of sulfa drugs in the treatment of infection has long been apparent to us since for over seven years we have been treating sulfa drug failures, known more euphemistically as sulfa-resistant infections. Continued work in the treatment of sulfa drug failures has greatly strengthened our original belief that sulfa sensitive infections are easily and favorably influenced by ultraviolet blood irradiation therapy and that a large variety of infections not controlled by sulfa drugs can be rapidly and efficiently controlled by ultraviolet blood irradiation therapy.

In sixty cases of sulfa drug failures ultraviolet blood irradiation therapy was found successful in controlling the acute infection in most instances. As might be expected, acute infections of apparently a virus or virus-like nature were found, when treated by sulfa drugs, to be either uninfluenced or, as occurred in a majority of cases, the infection was believed to have spread more rapidly than ever following the use of sulfa drugs. This was in sharp

contrast to the rapid subsidence of such infections when treated with ultraviolet blood irradiation therapy alone or after sulfa drug failure.

It is our carefully considered opinion that, in the treatment of most acute pyogenic infections and some virus-like infections, ultraviolet blood irradiation therapy is a far safer and much more efficient method of treatment than is chemo-therapy with sulfa drugs.

*Treatment of Penicillin-Resistant Infections.* In penicillin-resistant cases, we have found that ultraviolet blood irradiation therapy is a valuable therapeutic agent when used to control penicillin-resistant infections, whether of acute pyogenic type or the virus or the virus-like type.

The chief penicillin-resistant infections in which we have used ultraviolet blood irradiation therapy to control the infection have been those due to *Streptococcus hemolyticus* and *colon bacillus* and those of a virus or virus-like nature.

As a result of our experience in the use of ultraviolet blood irradiation therapy in penicillin resistant cases, we have been able to make the following pertinent observations:

(1) As might be expected, patients who have received penicillin without effect do not come to us as a rule with the profound toxemia that is so uniformly present in sulfa drug failures. Since no extra toxic burden has been added to the patient by the drug used, more can be expected from the use of ultraviolet blood irradiation therapy in pure penicillin resistant failures than in sulfa drug failures, provided that patient is not first seen in a hopelessly moribund state.

(2) There is no contraindication to the combination or synchronized use of penicillin with ultraviolet blood irradiation therapy, as is the case with sulfa drugs. Penicillin can be given safely before, during or immediately after ultraviolet blood irradiation therapy, since there is no photosensitization factor to be considered.



(3) Inasmuch as ultraviolet blood irradiation therapy controls certain virus or virus-like infections rapidly and efficiently and penicillin does not, ultraviolet blood irradiation therapy must be considered the procedure of choice in these infections.

(4) The rapid and favorable response of *Staphylococcus septicemia* to either penicillin or ultraviolet blood irradiation therapy used independently of the other, plus the lack of contraindication to a combined use of both agents, suggests that the ideal treatment for all severe staphylococcal infections is the combined treatment of the infection, using both ultraviolet blood irradiation therapy and penicillin simultaneously.

(5) Ultraviolet blood irradiation therapy by its very non-specificity has many advantages over penicillin in that it provides safe, rapid and efficient control of acute fulminating infections, regardless of whether or not such infections are due to penicillin-sensitive bacteria.

*Blood Irradiation Alone in Acute Infections.* (1) Ultraviolet blood irradiation therapy used alone is, in our opinion, the ideal method of controlling acute bacterial infections either of an acute pyogenic nature or of a virus-like character.

(2) It is a safe, reliable and non-specific method of controlling acute infections.

(3) It insures adequate ultraviolet intake to those whose protective immunological reactions are in the process of deterioration. This deterioration, even when progressing rapidly, has been observed to be reversed in a definite manner following ultraviolet blood irradiation therapy, resulting in consistent clinical improvement.

(4) A marked decrease in hospitalization time for such infections has been observed by us as well as other workers in the field<sup>5,6,7,8</sup> following the use of this method.

(5) When blood irradiation was used in the acute infections reported here, the use of sulfa drugs or penicillin was believed to be entirely unnecessary, with the possible simultaneous use of penicillin in *Staphylococcus septicemia* and the absolute use of penicillin in bacterial endocarditis.

(6) The detoxification effect originally reported to occur twenty-four to forty-eight hours after the use of ultraviolet blood irradiation therapy in acute pyogenic infections was also noted after its use in virus or virus-like infections. This finding has also been recorded by Barger<sup>15</sup> and Newman<sup>16</sup> in acute bulbar poliomyelitis patients following ultraviolet blood irradiation therapy.

*Preoperative Protective or Rebbeck Effect.* Rebbeck originally described the occurrence of a powerful preoperative effect following the use of ultraviolet blood irradiation therapy before operation, i.e., uterine dilatation and curettage in cases of incomplete septic abortion.<sup>8</sup> We have repeated this work in twenty-six consecutive cases and can definitely confirm this original report of Rebbeck's. We have likewise found that one may remove with impunity infected teeth and tonsils in the face of an acute rheumatic process with or without associated myocardial damage.

The tremendous potentialities for preoperative protection should be obvious to both surgeon and internist who are constantly faced with the well known dilemma of the poor surgical risk patient with dangerous foci of infection producing or aggravating the chief disease process.

It seems to us that Rebbeck's contribution to safer surgery is most important; furthermore, his preoperative protective effect has been confirmed by others besides ourselves, notably Hancock,<sup>5</sup> Moser,<sup>6</sup> Olney<sup>7</sup> and Barrett.<sup>8</sup>

#### SUMMARY

1. The study of the clinical effects of ultraviolet blood irradiation in 445 consecutive and unselected cases of acute pyogenic infections has been made. Confirmation of our original preliminary findings was observed. These findings showed that ultraviolet blood irradiation therapy was a rapid, efficient and non-specific control of all types of acute pyogenic infections (except bacterial endocarditis), the use of which was characterized by a quick subsidence of toxic symptoms, a disappearance

of bacterial proliferation and invasion and an uneventful convalescence.

2. In seventy-four consecutive and unselected cases of virus or virus-like infections we have observed results comparable to the favorable effects observed in its use in acute pyogenic infections.

3. It was found that sulfa sensitive infections are easily and favorably influenced by ultraviolet blood irradiation therapy and that a large variety of infections not controlled by sulfa drugs can be rapidly and efficiently controlled by ultraviolet blood irradiation therapy.

4. Many penicillin-resistant infections respond favorably to ultraviolet blood irradiation therapy, both the acute pyogenic types and the virus or virus-like infections.

5. We were able to confirm the preoperative protective effect of ultraviolet blood irradiation therapy described by Rebbeck and fittingly called the Rebbeck Effect.

6. There is no contraindication to the joint use of penicillin and ultraviolet blood irradiation therapy, but sulfa drugs cannot be safely used in the first four or five days following ultraviolet blood irradiation therapy.

#### CONCLUSIONS

1. Ultraviolet blood irradiation therapy is in our opinion the safest and most efficient method of controlling most acute pyogenic infections with one notable exception, namely, subacute bacterial endocarditis.

2. Ultraviolet blood irradiation therapy in our opinion is the procedure of choice in the treatment of sulfa-resistant and penicillin-resistant infections of the acute pyogenic infection type.

3. Ultraviolet blood irradiation therapy is the procedure of choice in the treatment of acute infections of a virus or virus-like nature, and should be tried out universally for such infectious disease processes.

4. The preoperative use of ultraviolet blood irradiation therapy allows the safe removal of foci of infection in such serious

disease as incomplete septic abortion with or without an associated septicemia, acute rheumatic fever with or without extensive myocardial damage, acute exacerbations of chronic rheumatoid arthritis and advanced bronchial asthma.

5. It is our belief that staphylococcemias can be most effectively controlled by joint use of penicillin and ultraviolet blood irradiation therapy.

6. These results are in close agreement with those obtained by other workers in this field.<sup>9-15</sup>

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# MYOPHAGISM CONGENITA\*

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THE atrophy or wasting away of muscular tissue which is found in arthrogryposis multiplex congenita is caused by a primary muscular degeneration with secondary joint changes manifested by severe contractures involving the extremities. Myophagism is the descriptive term which in one word seems to best fit the type of muscular atrophy found in this condition. The following descriptive terms have been used in the past by these authors: Stern<sup>3</sup>—arthrogryposis multiplex congenita; Middleton<sup>8</sup>—myodystrophia foetalis deformans; Sheldon<sup>7</sup>—amyoplasia congenita; Rocher<sup>6</sup>—multiple congenital articular rigidity.

A. G. Otto<sup>1</sup> in 1841 was the first to describe this anomaly. In 1905, Rosenkranz<sup>2</sup> attempted to explain the etiology. In 1923, Stern gave it the name arthrogryposis and discussed the etiology. In 1925, Lewin<sup>4</sup> gave the derivation of the term coined by Stern. In 1932, Sheldon described the condition from the view point of a degenerative muscular atrophy and called it amyoplasia congenita. In 1934, Middleton discussed the comparative pathology, called it myodystrophia foetalis deformans and drew an analogy between this condition and the muscular dystrophies of post-natal life. In 1943, Badgley<sup>9</sup> attempted to describe the etiology as due to a failure of normal rotation of the limb bud.

The fact that there have been several theories as to the cause of this condition proves that this has not been definitely settled, but most of the extensive studies seem to indicate that the cause of the deformities is a muscular degeneration with secondary joint changes. The joints are formed normally and the epiphyses

are normal. The contractures of the muscles produce malformation of the major joints. Stern stated that the etiology may be due to pressure on the fetus resulting in contractures. A history that the mother did not experience "quickening" until the sixth month of pregnancy which soon faded away entirely is usually obtained in the majority of instances. Stiffness of the joints results from lack of fetal motion; this is in keeping with embryological evidence from limb buds transplanted into regenerating paralyzed muscle. Middleton in his investigations found that the muscles of lambs were very wasted and composed largely of fat and that among the fat could be seen occasional oval cells with central nuclei. These cells were clearly muscular in type and could be interpreted as undeveloped muscle cells in the myoblastic stage of differentiation or degenerating myocytes. Hutt<sup>10</sup> described a hereditary lethal muscle contracture occurring in calves and mentions that this condition may be found in other species of the artiodactyla. Roberts<sup>5</sup> described a similar congenital deformity occurring in lambs. The deformity was transmitted in sheep as a simple autosomal recessive factor described as "stiff jointed lambs." The deformity consisted of the presence of contractures of the muscles of the limbs with limitation of motion in the joints which were themselves normal on dissection. The muscles were found degenerated and the muscle fibers replaced with fat in the full term lamb. Sections of muscles removed from the premature animals showed degeneration of the muscle fibers with secondary fat replacement. There were no abnormalities found in the central nervous system or peripheral nerves, and

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FIG. 1. Case 1. Dislocated hips, the result of contracture and shortened gluteal muscles.



FIG. 2. Excellent reduction of dislocated hips obtained by abduction.

electrical tests of the affected muscles revealed no response or a weak normal result. The reaction of degeneration is never present. In the human the muscles of the diaphragm are apparently normal but in animals this organ consists of a fibrous sheet with little or no muscular tissue which accounts for the respiratory failure and death at birth. The muscles although abnormal are present. The muscles of the limb bud are a later development than those of the trunk and arise from a different source which accounts for the fact that the limb muscles alone are affected. The muscular degeneration has its onset about the third to the fourth month of fetal life and progresses rapidly reaching its maximum and ceases at birth.

This is a fascinating subject and the ingenuity of the orthopedic surgeon will be taxed to the utmost as to correction of the deformities and makes what at first appears a hopeless situation into one that modern orthopedic surgery can with persistent effort overcome. The mentality of the patients affected is usually within the average normal and since they are handicapped because of the marked deformities consisting of club hands, club feet and contractures of the major joints it is conceivable that these unfortunate individuals may be treated as domicile and institutional patients. It has been stated that it is characteristic of the dislocation of the hip joints that the reduction is difficult. In

one of our patients (Figs. 1 and 2) an excellent reduction was obtained by simple abduction over a long period of time. The coxa vara deformity may be produced by the shortened gluteal muscles pulling up the trochanter. (Fig. 3.)

Plastic and reconstructive surgery can do much to help make more than a bed-ridden patient of these handicapped children. The use of fusions, osteotomies, capsulotomies, manipulations and stretchings are some of the procedures which have been used and should be attempted; for everything is to be gained and nothing lost in the treatment of these patients. Each procedure requires prolonged hospital care and these children are best treated in a crippled children's hospital where expert physiotherapy, occupational therapy and attendance at school can be attained. Ambulation of these patients is a problem

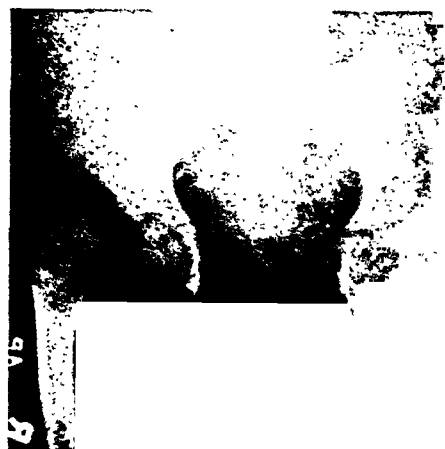


FIG. 3. Case 11. Coxa vara deformity.



FIG. 4. Case I. Result of supracondylar osteotomy right femur, enabling patient to stand and walk with crutches.

which must eventually be considered. One of our patients afflicted with a severe involvement is now walking with crutches. Following is an account of three patients who were treated with reconstructive surgery:

**CASE I.** This patient presented a severe contracture of both upper and lower extremities. Both hips were dislocated (Figs. 1 and 2) and during the course of her early treatment the hips were maintained in abduction and an excellent result was obtained. A supracondylar osteotomy of the right femur was done recently and it is contemplated that a similar procedure be done on the left femur. The patient can now walk with the support of crutches. (Fig. 4.) This is considered an achievement considering

the fact that she was a bedridden and wheelchair patient for a long time.

**CASE II.** This nine-year old boy was treated for correction of his club feet by subastragalar fusions and tendon lengthenings of the heel cords. A resection and capsulotomy of the right elbow joint to correct severe contracture was performed with good results. Figure 3 demonstrates the coxa vara deformity of the hips. It is contemplated that reconstruction of the left elbow and both hands be done, plus supracondylar osteotomies of both femora in order to correct the flexion deformity of the knee joints. (Fig. 5.)

**CASE III.** This boy was the sixth of seven children. There is a history of a difficult labor. At birth the upper extremities were internally rotated and the elbows extended with contractures of both axillae. The lower extremities



FIG. 5. Case II. Severe muscular degeneration with contractures of extremities.



FIG. 6. Case III. Range of motion of upper extremities.

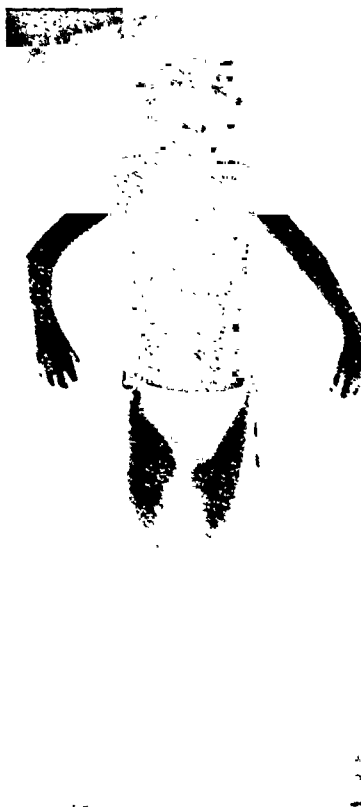


FIG. 7. Case III. Contracture of both axillae; muscular atrophy about shoulders; correction of feet.

were normal except for the right foot which presented a mild varus deformity. This patient received intensive physiotherapy and manipulations and at the present time he has useful upper extremities as demonstrated in Figures 6 and 7. The foot was treated by manipulation and corrective shoes.

Myophagism congenita has been selected to describe this peculiar symmetrical atrophy or wasting of muscular tissue. The term is derived from the Greek meaning, "to consume muscle tissue." The reaction is of a phagocytic nature occurring prior to birth and it is selective in that the extremities alone are involved.

#### SUMMARY

A primary muscular degeneration with secondary joint contractures is discussed. Myophagism congenita which is derived from the Greek meaning, "to consume muscle," is the term selected to describe

the condition. The comparative pathology and the orthopedic treatment is stressed.

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# USE OF TANTALUM FOR FACIAL AND CRANIAL DEFECTS

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THE search for a metal or metallic alloy suitable for tissue replacement has been going on since the sixteenth

the operating room. It is difficult to carve a piece of bone or cartilage to fit a defect on one side of the face and expect it to



FIG. 1. Facial defect; preoperative.



FIG. 2. Same case as Figure 1, post-operative.

century. Gold, silver, steel, aluminum, magnesium, brass and Vitallium have all been used. However, all these metals oxidize in body fluids, provoke foreign body response and show high electrolytic reaction. Most serviceable metal in this group is Vitallium which, prior to the introduction of tantalum, was most successfully used.

*Advantages of Tantalum.* Tantalum seems the best metal now available for the repair of cranial and facial defects. It is an element with many unique properties. Blue-gray in color, it has the characteristics of mild steel. In its annealed state, it is ductile and workable. Biologically, it seems inert. Experimental evidence indicates that it becomes encapsulated without continuous progressive "piling up" of tissues. This is an important quality. It is more useful than Vitallium because the latter cannot be cut, shaped or trimmed in

match the contour on the uninjured side. With tantalum this can be done.



FIG. 3. Same case as Figure 2; tantalum plate in place.





FIG. 4. Facial defect; preoperative.

FIG. 5. Same case as Figure 4; postoperative.



FIG. 6. Facial defect; preoperative.



FIG. 7. Same case as Figure 6; postoperative.



FIG. 8. Same case as Figure 6; roentgenogram showing tantalum plate.

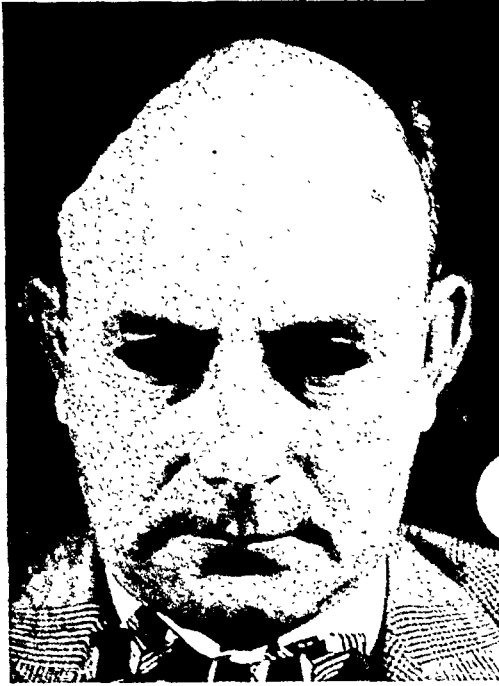


FIG. 9. Cranial defect; preoperative.

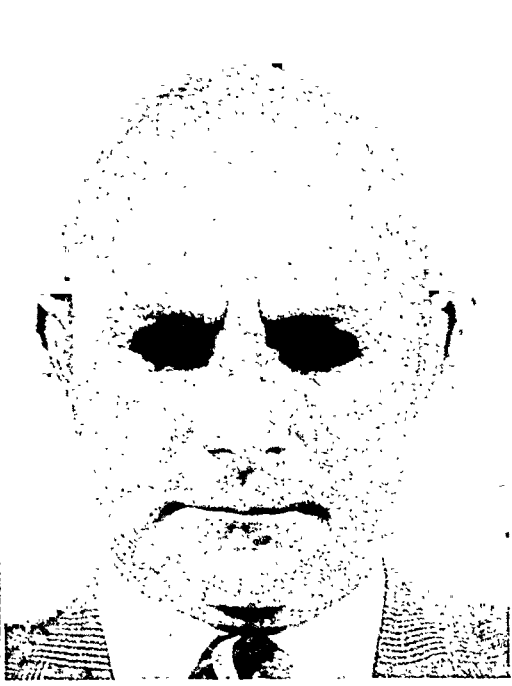


FIG. 10. Same case as Figure 9; post-operative.

*Technic.* Tantalum is serviceable for the repair of facial and cranial defects of all sorts, and can be used in a one-stage technic. A moulage of the defect is first taken; and on this, the repair is built up with wax. From this model, a die and a counter die are made. The tantalum plate is made and pressed out. Little additional modelling or trimming is necessary to make the plate fit.

Patients with contour defects of the face, especially if war casualties, invariably have a great deal of scar tissue. This scar tissue should be excised through the original laceration. A new incision extending through the old laceration should be avoided if possible to prevent future necrosis of some skin flap. Strict hemostasis is essential because an infected hematoma cannot be evacuated without sacrificing the plate.

*Facial Defects.* The use of tantalum for facial defects has not, so far as I know, been previously reported. However in battle wounds and other injuries of the face, where portions of the orbital rim or zygomatic arch are lost, tantalum plates can be made that will accurately reproduce the facial symmetry. In repairing an

orbital rim or zygomatic defect, the tantalum plate is anchored at three points like a tripod. These sites are determined in advance. In the laboratory, perforations are made to hold the tantalum wire for fixation. I usually make additional perforations at the approximate anchor site to avoid the necessity of drilling these in the operating room. Nevertheless, an electric dental drill should be part of the sterile operating kit. Holes, one quarter of an inch

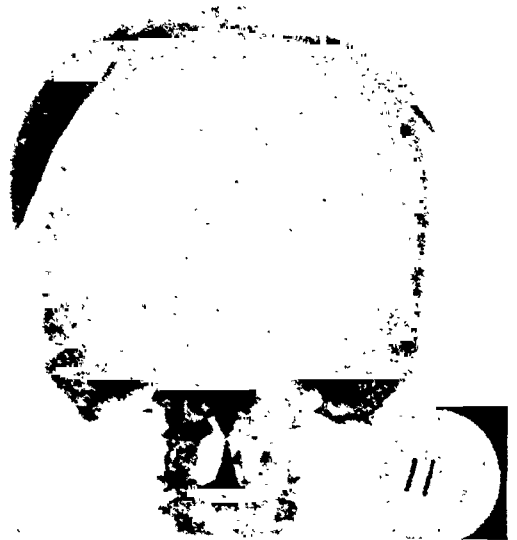


FIG. 11. Same case as Figures 9 and 10; tantalum plate in place.

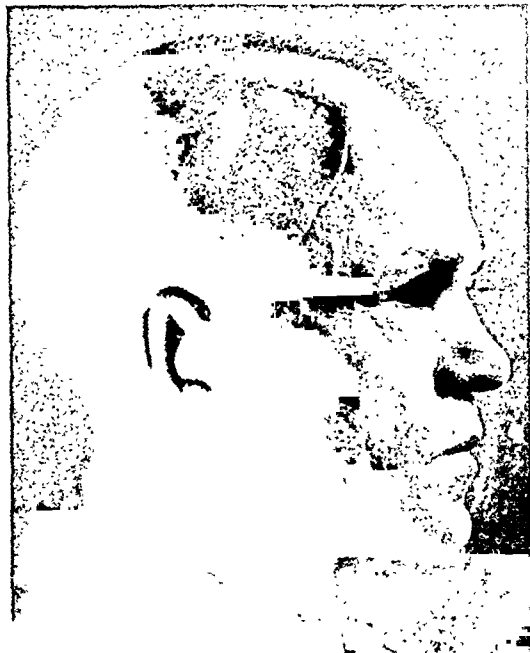


FIG. 12. Cranial defect; preoperative.



FIG. 13. Same case as Figure 12.

in diameter are made in the plate to allow for drainage. Figures 1 to 8 illustrate the methods and results.

*Cranial Defects.* When cranial defects are being repaired with tantalum, the skull is wedged, the plate fitted in, and a small triangle (similar to a glazier's triangle) is hammered in between the two layers of bone to hold the plate fast. (Figs. 9 to 14.) Sometimes, after a tantalum plate is inserted into a skull, the operator finds

serum or blood under the flap overlying the plate. This is treated by tapping every other day, or daily if necessary. Tapping is done under strict asepsis. An elastic compression bandage is then applied over a sterile dressing.

*Disadvantages.* Some patients complain that they experience a little pain in the overlying skin during excessively hot or cold weather. This is the only objection made by patients to tantalum repairs.



FIG. 14. Same case as Figures 12 and 13; post-operative roentgenogram.

# STRICTURES FOLLOWING TRANSURETHRAL RESECTION

## COMMENTS ON THE INDICATION FOR THE OPERATION

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**M**OST of the strictures following transurethral resection occur in cases that have been resected with a Braasch Bumpus or a Thompson cold punch. These instruments are cold and would injure the urethra only by friction and trauma. Friction and trauma may be caused by one or more of the following factors: not enough room in the urethra for the instrument; insufficient lubrication; too many movements of the instrument sliding through the urethra; or rough grasping of the instrument while forcing the piece to be removed into the slot, thus increasing the friction and trauma by added pressure against the wall of the urethra on the side the bite is taken. Furthermore, when the triangular ligament is used as a fulcrum, while forcing the piece to be resected into the slot of the instrument, the mucous membrane lining of the urethra at this point is subjected to even greater pressure.

Pursuing this line of thought further, with the hope of evaluating these separate factors, the number of movements executed during an operation for prostatic obstruction was counted and recorded in fifteen cases, at clinics where the cold punch was used entirely, and also at clinics where the electric loop only was in use. The counting and recording was done with the aid of a Veeder-Root hand tally while these transurethral prostatic resections were done by experts in whose hands, "every little movement has a meaning all its own." Most urologists are not so highly skilled as these men in this particular phase of urology; therefore, generally, the number of movements would be greater, whenever a complete removal of the gland is attempted.

Recording the movements of the instru-

ment during the resection of small, medium and large prostates, at several different clinics, the author found, by actual count, that the number of movements with the McCarthy resectoscope and the Thompson punch instrument is about the same during orientation, the observation of the progress of the operation, and the stopping of hemorrhage. However, actual removal of the condemned area is attended with no movement that could cause injury to the urethra when the McCarthy instrument is used; but in the punch operation several things happen which may result in trauma. When removing tissue with the Braasch or Thompson punch, the instrument is shoved forward so that the slot is over the doomed area. Then, either by a pump-like action, using the triangular ligament as a fulcrum, or by sheer strength, the tissue to be removed is forced into the slot by pressing the instrument against the area to be resected. Maintaining this pressure, the tubular knife or punch is shoved home. The piece thus excised usually sticks to the instrument, obscuring the vision; in order to get rid of it the instrument is shaken vigorously.

By adding these biting and shaking movements to the movements concerned with the orientation and examination of the operative field in general, the progress of the operation, and the control of hemorrhage, one gets an idea of the chance for injury to the sensitive urethra.

The removal of one large prostate showed, on the tally counter, 2,000 movements; another case obstructed by a relatively small prostate recorded 750; while most cases were medium sized to large glands entailing from 1,000 to 2,000 movements. In the use of the two types of

instruments, then, the number of movements involved in the resection of a large gland compares as follows: McCarthy instrument—1,000 to 2,000 movements; punch instrument—1,000 to 2,000 movements, plus 150 to 250 times when great pressure is exerted against the wall of the urethra in the act of punching out tissue, plus 100 to 200 times when the instrument is shaken to rid it of the punched out tissue in order to clear the view.

Although the punch operation leaves live tissue and the electric loop a coagulated surface of devitalized tissue, the authors have seen more strictures following the cold punch method. This may be due partly to the preponderance of cases subjected to the punch operation over those done by the McCarthy method in this part of the country. However, the main reason is undoubtedly the fact that there is so much added chance of injury to the urethra during the actual removal of tissue, as described above, when the cold punch is used.

#### CASE REPORTS

CASE I. A. A., a white male, aged sixty-one, came to the hospital on March 19, 1943, complaining of inability to pass his urine. He gave a history of having been resected at a famous clinic with a Thompson resectoscope, one and a half years previously. For the past six months, he had noticed that his urinary stream was becoming smaller and smaller. An unsuccessful attempt was made to pass a catheter. There were strictures at the meatus, one inch proximal, and at the junction of the anterior and posterior urethra. A fine filiform was passed after several attempts. Followers, up to 18 F. were passed, but the scar would not yield beyond that. The patient was advised to have his strictures treated; however, as he feared all transurethral procedures, and as he could now pass his water better, he refused all further treatment. His strictures were undoubtedly due to the transurethral resection done one and a half years before, because, had they been present at that time, the resectoscope could not have been passed.

CASE II. E. R., a white male, aged sixty-

eight, was referred on May 14, 1944, by a general surgeon. He gave a history of having had a transurethral prostatic resection done with the punch instrument in 1938. He had noticed a progressively diminishing urinary stream. Physical examination showed the man in good general condition, but with a stricture at the meatus, another two inches proximal, and a third at the junction of the anterior and posterior urethra. The meatus admitted a No. 10 F.; the next stricture, a No. 8 F.; and the third, only the finest filiform. His residual urine was 600 cc. Prostate was enlarged, grade 2. There was no evidence of cancer. On May 16, 1944, under gas anesthesia, filiforms and followers, followed by sounds, were passed, dilating the strictures up to No. 22 F. Then a perineal prostatectomy<sup>10</sup> was done. Prostatic tissue removed measured 3 cm. by 5 cm. by 3 cm. Pathological diagnosis was "adenomatous hypertrophy of the prostate." This man was treated postoperatively as a case of traumatic urethral stricture.

CASE III. B. G., a white male, aged sixty, came in on October 15, 1945, with a history of having had a transurethral resection done six months previously. For the past month he had noticed a narrowing of his urinary stream until it had become a mere dribble. On questioning, it was brought out that he had heard, during the operation, only a buzzing noise; so he was undoubtedly resected with a McCarthy resectoscope. On examination, it was found that only a filiform could be passed into the bladder. The strictures, one two inches from the meatus, and one at the prostatic urethra, were very dense and hard to overcome. However, this man has been unusually cooperative, and at present the results are very good. Nevertheless, he will have to be watched carefully and to have sounds passed at regular intervals for the rest of his life.

These strictures would not occur if transurethral operations were done only on selected cases. Whenever a 30 F. sound does not pass easily; when the resectoscope passes in but seems to be grasped or held snugly by the urethra; when the prostatic urethra is abnormally long due to enlargement of the prostate; and when a short suspensory ligament makes it difficult or impossible to do a resection without applying great pressure with the instrument

against the mucous membrane of the urethra; it is better to do a conservative perineal operation or a suprapubic enucleation. However, should the patient's general condition demand a transurethral, even if one or more of the above listed contraindications exist, it should be done through an external urethrotomy. Nesbit<sup>6</sup> strongly recommends this procedure; Creevy and Webb are using it frequently; and the Mayo Clinic recommends its use wherever indicated.

Recently, in an excellent article, Orr, Kindert and Pyle<sup>7</sup> stated that it is a mistake to consider that the average urethra will easily accommodate a No. 28 F. resectoscope. Middleton<sup>4</sup> says that since he has used an external urethrotomy where the urethra was snug to a No. 28 F. sound, postoperative strictures have been "transformed from a bugbear to a memory."

The proponents of the different methods of treating prostatic obstruction have for years maintained their belligerent fronts, and at intervals have written articles<sup>11</sup> bristling with intolerance. Emmett,<sup>3</sup> recently, revealed a soft spot in his strongly fortified "front" when he said, "I have no quarrel with the surgeon who finds it the best procedure to care for eighty-five per cent of enlarged prostate glands by transurethral resection and fifteen per cent by open operation." This statement is pregnant with tolerance and good sense. Surely, in every doctor's practice, from general practitioner to specialist in urology, there will be from 15 to 25 per cent of the cases presenting themselves with prostatic obstruction who would be better off if cared for in the manner mentioned by Emmett and definitely outlined in this paper, rather than in the "run of the mill" manner which the larger clinics of this country are using at the present time.

There is a definite need for all three methods of operation for the relief of prostatic obstruction, and the three methods should be used in the following manner:\*

\* T. Millin,<sup>5</sup> working in London, recently reported twenty cases of Retropubic prostatectomy, go-

*I. Suprapubic.* (A) All cases of grade 4 enlargement who are from fair to good risks, and in whom there is no suspicion of cancer.\* By this method, with a benign enlargement, the time on the operating table can be very short;<sup>8</sup> while a complete removal of a large gland transurethrally cannot be done in less than one hour by most resectionists. Such a long time on the operating table is undesirable, and the removal of so much tissue involves 1,500 to 2,000 movements of the transurethral instrument. With the punch instrument another 250 bites and 200 shakings of the instrument must be added, increasing the probability of injury to the urethra.

CASE IV. N. T., a white male, aged sixty-four, presented himself, on February 13, 1945, with a history of having always been in good health except for the last two years, when he had had symptoms of increasing urinary obstruction. Physical examination showed the man in good general condition. Urine was clear. There was 500 cc. residual urine. The prostate was enlarged, grade 4, judged by rectal examination and the length of the prostatic urethra. Suprapubic prostatectomy was done on February 14, 1945. A Foley catheter was placed in the urethra with the bag injected to 20 cc. and pulled into the prostatic bed. Convalescence was uneventful. The Foley catheter was removed on the ninth day, at which time the suprapubic wound was dry. The patient passed his water normally and went home on the eleventh postoperative day. A letter from him two months later says, "I am sixty-five years old today and in good health. My waterworks functions fine and the world looks brighter."

CASE V. O. L., a white male, aged fifty-eight, came in on January 16, 1945. He gave a history of good health up to two years ago, when he began having to get up at night to pass his water. The doctor, by whom he was referred, had found it necessary to catheterize him on

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ing through the prevesical space, the gland being attacked distal to the bladder. He says that this method "bids fair to supplant" those now in use.

\* Enucleation is difficult in the presence of cancer, and a cure cannot be expected unless the capsule is also removed; the operation is prolonged, and the bladder may be torn loose, increasing chances of shock, hemorrhage and infection.

several occasions. Physical examination showed the man in good general condition. Residual urine measured 300 cc. The prostate was enlarged, grade 4, judging from rectal examination and the length of the prostatic urethra. There were no nodules felt by the examining finger, and the gland was not fixed. The urethra accommodated a 30 F. sound. The patient was advised to have a suprapubic prostatectomy done, but the operation was refused; a transurethral resection was demanded. He was told that more than one resection would be necessary with such a large gland, and that his hospital stay would be much longer; but fear of the old suprapubic operation was strong enough to override common sense in submitting to his doctor's advice. On January 19, 1945, a transurethral resection was done using the McCarthy resectoscope. Considerable bleeding was encountered, and only 30 Gm. was removed from 12 to 4 clockwise, and from 12 to 8 counter-clockwise. A Foley catheter with a bag inflated to 30 cc. was left in the bladder. One week later, the main mass of the gland was removed; bleeding at this stage was moderate and easily controlled. A Foley catheter was placed in the bladder as before. It was removed two days later, but the patient could not urinate. The catheter was reinserted and each day removed to see if the patient could pass his water, but without success; so, one week following the second stage, a third resection was done and 30 Gm. more tissue was resected. Two days later, the catheter was removed and the patient passed his water normally. He went home on the 24th day after his admittance to the hospital. He was still running a temperature of 100°F. in the afternoons, and he had considerable pus in his urine. One month after leaving the hospital, his urine was still slightly cloudy. It cleared up about six weeks after he arrived home.

If the patient in Case v had been treated in the same manner as the one in Case iv, their postoperative courses would most likely have been practically identical. In the future, patients like the one in Case v will be advised to have a suprapubic prostatectomy done, since this, as in Case iv, is definitely the operation of choice. Should the patient insist on transurethral resection, as many will do because of the operation's publicity, he will be referred

to a place where transurethrales are done exclusively.

*II. Perineal.* (A) All cases of early cancer in whom a worth while percentage of cures may be expected by the removal of the entire gland, including the capsule.

CASE VI. E. W., a white male, aged seventy-six, presented himself on July 6, 1943. He gave a history of urinary difficulty extending over the last four years, but for the last month, his family physician had been forced to catheterize him several times. Physical examination showed him in good general condition. His blood pressure was 150/80. Urine was clear with a specific gravity of 1019. It contained albumin but no sugar. Microscopic examination showed no red blood cells, but a few leukocytes. Blood examination showed 92 per cent hemoglobin. Non-protein nitrogen was 22.9 mg., and creatinine was 1.5 mg. per 100 cc. of blood. Wassermann was negative. On rectal examination, an enlarged gland containing several hard nodules was felt. The gland was not fixed in the pelvis, but could be moved by the palpating finger. A diagnosis of early cancer was made and a radical perineal operation was advised and accepted. This was done on July 8, 1943. The prostate, with capsule intact, was removed. A Foley catheter was passed through the urethra and into the bladder. No effort was made to suture the urethra to the bladder, and no special invitation was extended to the colon bacilli around the anus by inserting a drain. Sulfa crystals were placed in the wound as it was closed. Dead spaces were obliterated and all bleeding controlled. The wound was closed tight using a subcuticular stitch so as to leave no extra holes in the skin, and a dressing of collodion with sulfa crystals was applied. The Foley bag was injected with 75 cc. water and a gentle pull was maintained for six hours with the aid of a rubber band from the catheter to adhesive around the upper end of the tibia. The catheter was left in situ for fourteen days. The microscopic pathological diagnosis was cancer, grade 2. On the seventeenth postoperative day, the patient left the hospital. He had no difficulty in passing his water and had good sphincter control. He was given stilbestrol, 1 mg. daily. He was treated postoperatively as a case of traumatic stricture. Unfortunately, this man died later of metastasis.

The authors regret that they have no case of cancer of the prostate to report in whom they have obtained a cure; however, several men<sup>1,11</sup> doing a greater number of radical perineals for cancer have reported varying percentages of cure.

(B) All cases in which cancer is not suspected and which are judged to be from fair to poor risks, but in whom some contraindication to transurethral resection exists. In such cases a conservative perineal operation<sup>10</sup> is the operation of choice.

CASE VII. An internist had been treating J. L., aged fifty-five, for nephritis, cardiac insufficiency and high blood pressure. Upon finding a large prostate and residual urine of 500 cc., he referred the patient with the request that the prostatic obstruction be corrected. On May 2, 1945, his blood pressure was 225/125; blood chemistry showed non-protein nitrogen 20, creatinine .6; blood count showed 4,200,000 red blood cells, 8,000 white blood cells, hemoglobin 85 per cent; urinalysis showed albumin 1 plus, sugar 0, specific gravity 1020. The prostate was enlarged, grade 3, with no evidence of cancer. The small caliber of the anterior urethra made it impossible to pass a resectoscope. If a resection were to be done, it would have to be done through an external urethrotomy. Because the patient's blood pressure was so high and the gland was so large, the operation would have to be done in two stages; bleeding would necessitate so much attention that enough tissue could not be resected in the allotted time. However, a two-stage resection in such a case would mean re-entering through the urethrotomy wound with chances of stricture of the urethra following. Therefore a conservative perineal enucleation, as mentioned above, was considered the operation of choice. This was done on May 8, 1945. Recovery was uneventful.

III. *Transurethral.* (A) All cases of obstruction due to moderate enlargement of the prostate<sup>8</sup> in which the caliber of the urethra is 30 F., and in whom there is no suspicion of early cancer.

CASE VIII. C. S., a white male, aged fifty-five, came in on May 15, 1945, complaining of inability to pass his water at times. He gave a history of having had to be catheterized on

several occasions. Upon examination he was found to have 200 cc. residual urine; on rectal examination, a slightly enlarged gland with no hard nodule was found; on cystoscopy, an enlarged median lobe was seen. He was advised to have a transurethral resection, which was done on May 24, 1945.

(B) All cases of advanced cancer of the prostate.\*

CASE IX. A. J., aged seventy-four, presented himself on January 4, 1945, giving a history of progressive urinary obstruction, with some recent sciatica. Physical examination showed the man in good general condition. His blood pressure was 150/90; urine was clear and negative for albumin and sugar. There was 300 cc. residual urine. On rectal examination a large prostate, grade 4, was found, frozen in the pelvis. A diagnosis of advanced cancer of the prostate was made. A transurethral resection was advised and accepted. On January 8, 1945, under spinal anesthesia, 90 Gm. of tissue was resected with the McCarthy resectoscope. Convalescence was uneventful. The microscopic pathological diagnosis was "adenocarcinoma, grade 2." He left the hospital on the eighth postoperative day and was given stilbestrol, 1 mg. daily. One month postoperatively, his urine contained many pus cells, but he had no sciatica. Two months after the operation, the urine was clear. A letter from him, dated April 7, 1945, says, "I have no pains whatsoever and am feeling fine."

(C) Poor operative risks, including those whose glands may be very large but who would be safer under repeated resections than if done by the conservative perineal method.

CASE X. M. B., a white male, aged eighty-four, presented himself on May 2, 1945. He complained of frequent urination which disturbed his sleep. On examination his residual urine was found to be 400 cc. Urinalysis showed: specific gravity 1010; albumin 2 plus; sugar 0. His blood chemistry showed non-protein nitrogen, 40; creatinine .6; 5,000,000 red blood cells; 10,000 white blood cells; hemoglobin 90 per cent. Since the caliber of his urethra was adequate, he was advised to

\* Stilbestrol and castration have been found of definite value, especially in relieving pain.



have a transurethral resection, which was done on May 4, 1945. Two days later, the catheter was removed and he passed his water freely. On May 8, he had a cerebral hemorrhage which paralyzed his left arm and leg. Recovery was partial and he left the hospital after three weeks.

When a transurethral seems to be the operation of choice, but some anatomical contraindication exists, external urethrotomy (which in itself may result in urethral stricture) must be added to transurethral resection. With this in mind, the case must be reviewed. The advantages and disadvantages of each method should be weighed. Using his best judgment, common sense and honesty,\* the surgeon should decide upon the type of operation best suited for the case at hand.

The object of this paper is to call attention to the enormous traffic in the urethra during transurethral resection, and also to point out to the reader that there are *definite* and *important* indications for the employment of each one of the three methods of operation for the relief of prostatic obstruction. It is high time to dispel the myth which prevails in certain parts of the United States, but nowhere else in the world, namely, that all prostatic obstructions can and should be handled in the same manner.

One is reminded of the controversy concerning the treatment of peptic ulcer which raged twenty-five or thirty years ago, when some men claimed that all peptic ulcers should be treated by performing a gastroenterostomy; while another group of men, equally insistent, treated all such cases medically. A little later, certain European clinics recommended gastric resection as applicable in all cases. Each one of these three methods of treatment has long since found and occupied its respective place in

the treatment of peptic ulcer. The controversy concerning the treatment of prostatic obstruction is analogous. There are three different types of treatment. The claims for each type are just as insistent. And, as in the case of peptic ulcer, each type of treatment will assume its logical place in the management of prostatic obstruction, contingent upon the clinical entity at hand, and not upon the geographical location of the urologist.

#### SUMMARY AND COMMENT

The occurrence of strictures of the urethra following transurethral resection seems to be increasing.

With a Veeder-Root Hand Tally counter, the movements of the instrument within the urethra in transurethral resection have been counted, revealing an astounding number of such movements.

This study also shows that resection by the punch method, as compared with the McCarthy method, is accompanied by added trauma due to the bites and the shakings necessary, as well as to the increased pressure applied in the removal of tissue with this instrument.

The need for a choice of operation to fit each individual case is stressed. It goes without saying that the urologist of the future, doing prostatic surgery, will have to have training enabling him to do suprapubic, perineal and transurethral operations equally well; so that his judgment of which operation is indicated in each individual case will not be hampered by the fact that he has had special training in doing perineal operations; or that he is a general surgeon and only trained to do the suprapubic operation; or by the fact that his intensive training in transurethral surgery has made him into a mere resectionist.

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\* Urologists of fame have stated that the operation of choice is the one in which the individual operator is most adept. Although this is true to a certain extent, it does not consider the patient entirely; it might be better to refer him to another surgeon who is more skilled in the type of operation which best suits the needs of this particular patient.

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WHEN strictures of the urethra cannot be treated by dilatation, or when quick results are desirable, internal urethrotomy is indicated. This operation is not to be attempted when an instrument cannot be passed through the stricture.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

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# Case Reports

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## SOLITARY PYOGENIC ABSCESS OF THE LIVER

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**H**EPATIC abscess may be divided into two groups: (1) Amebic, which is by far the largest group and (2) pyogenic. This latter group may be divided into two subheads (a) multiple liver abscesses and (b) solitary liver abscesses. The subject of the solitary pyogenic liver abscess will be considered in this paper and three cases reported.

**CASE I.** A colored male, age twenty-five, was admitted to the hospital with generalized peritonitis on July 16, 1941. The patient had been sick with abdominal pain, nausea and vomiting, and loss of appetite for several days before reporting to the hospital. As there were no signs of localization of the process and the patient's general condition was good, the abdomen was opened and a gangrenous ruptured appendix removed on the date of admission. The abdomen was drained through a stab in the right lower quadrant.

The patient had a stormy postoperative course. Wangensteen suction was used continuously and intravenous fluids given. The patient had a fever of 101°F. to 99°F. for nine days postoperatively, then for several days he showed improvement and had a temperature of only 99°F. Following this, the temperature again went to 100°F. and 101°F. and on the twenty-first postoperative day he had a chill and the fever rose to 103°F. The patient complained of mid-abdominal pain at this time. By the twenty-third postoperative day there was c-v angle tenderness and the fever remained at 103°F. A diagnosis of liver abscess was made clinically on the twenty-fifth postoperative day. Fluoroscopy revealed an elevated right hemi-diaphragm with approximately one-third limitation of motion of the right hemi-diaphragm as compared to the left. On the twenty-sixth postoperative day an x-ray film showed elevation of the

right diaphragm and the following day a further increase in elevation.

On August 13, 1941, the twenty eighth post-operative day, the patient became worse with marked restlessness, pain in the right upper abdomen at the anterior axillary line, nausea and vomiting. The temperature was 103°F., pulse 100 and respiration 24, with a cough suggestive of diaphragmatic irritation. The abdomen was explored through a right paracostal incision and the right lobe of the liver was found to be greatly enlarged upward with many fine adhesions between it and the diaphragm. Drains were inserted to promote formation of adhesions with walling off of the process from the peritoneal cavity. The wound was closed loosely around the drain. On August 16, 1941, three days after surgery, the abscess ruptured spontaneously and drained a large amount of yellow pus through the paracostal incision and no further surgery was needed. Bacteriological studies were not done. On August 8, 12, 20 and 30, 1941, 500 cc. whole blood transfusions were given. The patient had a high temperature for seventeen days following drainage of the abscess, then became afebrile and was out of bed in a wheel chair on the twenty third day after operation for drainage of the liver abscess. Chemotherapy with intravenous sodium sulfathiazole was started two days before the operation for exploration of the liver and continued for ten days postoperatively. A total of 28 Gm. was given over this period. The patient was discharged cured on September 28, 1941, after regaining his normal weight. He was examined one year later and was in good health.

**CASE II.** A white male, age thirty-eight, was admitted to the hospital September 22, 1944, with the following history: the patient was feeling well until 6:00 A.M. on the day of admission when he was awakened with a shak-

ing chill. This was followed by fever, weakness, nausea and vomiting. The nausea and vomiting were not marked. On the way to the hospital, he developed a "catchy" pain under the right rib margin associated with deep inspiration and coughing. This pain was present for only a short time and then disappeared. He had a slight cough for the past twenty four hours which was not productive of sputum. For the past one month he had occasional dull pain in the right shoulder uninfluenced by movement of the shoulder but aggravated by carrying anything for a long period of time. The remainder of the history is unimportant.

Examination revealed a well developed and well nourished white male who appeared to be acutely ill with a temperature of 103°F., pulse 116 and respiration rate of 26. Positive findings on examination: dullness over the lower lung with diminished breath sounds and occasional crepitant rale throughout this area. Examination of the abdomen: liver dullness, seemed to be enlarged upward on percussion but the liver was not palpable. The spleen was palpable. The white blood count on admission was 11,400 with 74 per cent segments. A diagnosis of right lower lobar pneumonia was made. X-ray film of the chest on admission: marked doming of the right diaphragm in the mid-portion, raised  $1\frac{1}{2}$  interspaces above its normal position. No lung pathology visualized. Repeat films on the 25th and 30th showed little change from the original film. A diagnosis of liver abscess was made and the patient given a course of emitine hydrochloride with no symptomatic improvement. Stool examinations were negative for endamoeba histolytica. The patient's condition gradually became worse with marked loss of weight and strength. A continued septic type temperature occurred. During this same period, he was given a course of sulfadiazine, 1 Gm. every four hours for three days, and penicillin therapy was begun on October 1, 1944. It was continued through October 16, 1944, in doses of 30,000 Oxford units intramuscularly every three hours.

On October 3, 1944, the patient was operated upon and the abdomen explored through a right paracostal incision. A decision to operate through a right paracostal incision was made because the mass on the dome of the right lobe of the liver pointed anteriorly and it was not believed practicable to attempt to reach the

abscess by means of the Ochsner-Nather extra serous retroperitoneal approach. On exploration through the right paracostal incision, the gallbladder was moderately distended and contained a large stone. The organ was normal in appearance otherwise. The liver was enlarged one to two finger breadths below the costal margin. There was a soft mass in the liver substance on the anterior-superior aspect of the right lobe of the liver with many fine adhesions between the liver and the diaphragm. Several large vaseline gauze packs were inserted to the mass and around the lower margin of the liver in an attempt to stimulate production of adhesions with walling off of the disease process from the peritoneal cavity. The wound was then closed loosely around the packs.

Under sodium pentothal anesthesia on October 6, 1944, the original paracostal wound was reopened and on exploration inadequate walling off of the disease process by adhesions was found. The abscess cavity was carefully aspirated and about 30 to 40 cc. of thick greenish pus was removed. The abscess cavity was then filled with 10 cc. of sterile water containing 20,000 Oxford units of penicillin. Fresh vaseline gauze packs were then placed around the edge of the liver and down to the disease process. Crystalline sulfanilamide, 10 Gm., was sprinkled throughout the involved area and the wound again closed loosely around the packs. Following this procedure, there was marked clinical improvement and the patient became free of fever and was allowed out of bed four days following the second operation.

Cultures of the pus from the liver abscess isolated beta hemolytic, coagulose positive, staphylococcus aureus.

On October 8, 1944, the patient developed mild jaundice which persisted for several days and then cleared up.

On October 14, 1944, under sodium pentothal anesthesia, the paracostal incision was again reopened in the lower portion and exploration revealed adequate adhesions walling off the abscess from the peritoneal cavity. The soft mass on the dome of the right lobe of the liver was still present. An attempt was made to aspirate the abscess but nothing was obtained. The abscess was easily opened by blunt dissection with the finger and several cc. of bloody serous fluid escaped. This material

was clear and odorless. No pus was present. A Penrose drain was inserted in the abscess cavity and brought out through the lower end of the paracostal incision. The gauze packs were not disturbed. The wound was closed loosely around the packs and the drain with through and through sutures. Crystalline sulfanilamide was sprinkled in the wound and the abscess cavity before closing. The patient improved rapidly following this and was ambulatory on the second day following the third operation.

On October 19, 1944, the vaseline gauze packs and Penrose drain were removed under sodium pentothal anesthesia. The wound healed slowly and required secondary closure with stainless steel wire sutures.

Following the third operation, the patient developed a pleural effusion which required tapping once on October 26, 1944. This patient was early ambulatory after surgery and his general condition remained good, although a persistent fistula developed which drained for several weeks.

CASE III. A white male, age 26, was admitted to the hospital on December 25, 1944, complaining of pain in the epigastrium and upper left quadrant of the abdomen, chills and fever. The patient gave a history of being well until December 5, 1944, when he had a sore throat and chilly sensation and felt malaise with pain in the left upper quadrant of the abdomen. He was treated in another hospital for two weeks and discharged in good condition. Shortly after leaving the hospital he started on a trip across the United States by train and noticed during the trip a persistent dull pain in the "pit of his stomach." This pain became gradually more severe and was prominent in both the epigastrium and left upper quadrant. At the onset of the abdominal pain he had pain in the lower part of his chest on inspection. He had no cough and no nausea or vomiting prior to entering this hospital. On admission he complained of some pain in the chest on deep inspiration. The patient gave no history of diarrhea or bloody stools in the past.

Examination revealed a well developed and well nourished white male who appeared acutely ill with a temperature of 102°F., pulse 100 per minute and respiratory rate of 20 per minute. Positive findings on examination were: marked pallor of fascies, slight lag of

expansion on left side of thorax during respiratory cycle, scaploid abdomen with exquisite tenderness and muscle splinting over the epigastrium and upper left quadrant of the abdomen. An impression of a mass in the epigastrium was given but because of the muscle rigidity and extreme tenderness the examination was unsatisfactory. The white blood cell count was 17,000 with 86 per cent neutrophils, the red blood cell count was 3,750,000 and the hemoglobin was 65 per cent. Stool examination for endamoeba histolytica was negative. The icteric index was 3.9. The urine and smears for malaria parasites were negative. X-rays of the chest revealed fuzzy irregularities of both diaphragmatic contours with neither costophrenic angles sharply outlined because of slight effusion. Scout films of the abdomen were negative. Fluoroscopic examination of the chest revealed a high semi-fixed right diaphragmatic leaf as compared with the left. After receiving a 1000 cc. transfusion of whole citrated blood the patient was operated on. The abdomen was opened through a high right rectus splitting incision and a large mass to the left of the mid-line was found. This mass was the left lobe of the liver which was firmly adhered to the parietal peritoneum of the anterior abdominal wall. The remaining viscera were normal. Five Gm. of crystalline sulfanilamide were sprinkled in the peritoneal cavity, the incision closed and a firm dressing applied. A small incision was then made to the left of the mid-line and directly over the left lobe of the liver. This was carried through the abdominal wall and a large abscess cavity entered. Thick yellowish pus escaped. Soft rubber dam drains were then inserted into the abscess cavity after injecting 15,000 Oxford units of penicillin into the cavity (patient had received 30,000 Oxford units of penicillin intramuscularly for forty-eight hours prior to surgery and this was continued postoperatively for several days).

Smears and cultures from the abscess taken at the time of operation were sterile. A piece of the abscess wall was examined by the pathologist microscopically and a report of granulation tissue was made.

The wound drained moderately for eighteen days and then closed. The patient gained strength rapidly and on the fourth postoperative day his temperature became normal

where it remained. He was discharged from the Surgery Department in good condition on January 22, 1945. Two months later the patient was in good condition with both wounds healed.

*Incidence.* Ochsner and Debakey<sup>1</sup> reported 186 cases of liver abscesses over a period of ten years of which 139 were amebic and forty-seven pyogenic. Of the latter group 54.5 per cent were considered solitary pyogenic liver abscesses. In their large collected series of cases of liver abscesses only 28.8 per cent were solitary pyogenic abscesses. Eliason<sup>2</sup> and co-workers reported a series of forty-seven cases of pyogenic liver abscesses of which fifteen were of the solitary variety. During a ten-year period at Charity Hospital in New Orleans, Louisiana, Ochsner and Debakey<sup>1</sup> point out that out of 540,776 admissions there were only forty-two cases of pyogenic liver abscesses including both single and multiple abscesses. According to most authors the incidence is greater in males. In Ochsner's and Debakey's<sup>1</sup> series of pyogenic abscesses which include both multiple and solitary, thirty-three were in males and fourteen in females. In Rothenberg's and Linder's<sup>3</sup> series of twenty-four cases of solitary pyogenic liver abscess seventeen were in males and seven in females. Eliason and co-workers<sup>2</sup> report in their series of forty-seven cases of both multiple and solitary liver abscess an incidence of thirty males and seventeen in females.

There seems to be no racial difference according to most writers on the subject of both types of pyogenic abscesses of the liver.

Thus we see that hepatic pyogenic abscess of the solitary variety is not common. Most authors on the subject of pyogenic abscess of the liver fail to separate the multiple from the solitary, thus it is difficult to obtain true figures on this condition.

*Etiology.* Most authors state that appendicitis is the cause of pyogenic liver abscess in the majority of cases. Ochsner

and Debakey<sup>1</sup> state that of their series of both multiple and solitary abscess of the liver only five cases or 10.6 per cent were due to appendicitis. Rothenberg and Linder<sup>3</sup> were able to determine the cause in only two and probable cause in a third case of their series of twenty-four solitary abscesses. Of the two with known cause, one was due to ruptured peptic ulcer, another due to cholecystitis, and the third or probable case followed an attack of appendicitis that was operated twenty-six weeks before the onset of the symptoms of disease of the liver. These authors stress hematogenous spread from a focus of infection such as a carbuncle or tonsillitis as being the source in most cases of solitary abscess of the liver. Eliason and co-workers<sup>2</sup> in their forty-seven cases of pyogenic abscess state that 49 per cent were due to appendicitis. These authors quoted, with the exception of Rothenberg and Linder,<sup>3</sup> do not break their series down into the multiple and the solitary group, thus their figures are at variance with Rothenberg and Linder.<sup>3</sup> The causes of pyogenic liver abscess as listed by various writers who include both types of pyogenic abscesses together are as follows:

1. Appendicitis
2. Cholecystitis
3. Gangrenous hemorrhoids
4. Ruptured peptic ulcer
5. Trauma, penetrating and non-penetrating
6. Proctitis and sigmoiditis
7. Diverticulitis
8. Ulcerative cancer of the bowel

The cause of solitary liver abscess is often obscure. Even in the reports in the literature in which both multiple and solitary abscesses are lumped together the percentage of cases of unknown cause is high but whether this high percentage is due to the solitary or the multiple is not stated. In the experience of most authors, the cause of multiple liver abscess is often obvious, therefore, one assumes that the high percentage of unknown cause is probably due to the group of solitary abscesses

included in each series. Ochsner and Debaquey<sup>1</sup> in their forty-seven cases of both types, of which 54.5 per cent were solitary, could not account for 59.5 per cent as to causes. Eliason and co-workers<sup>2</sup> were unable to account for twelve out of their series of forty-seven of both types which included fifteen solitary abscesses. One of the cases in this report followed a ruptured appendix with generalized peritonitis. The second case was probably due to a low grade cholecystitis and the cause of the third case could not be determined. In the second case there was no history of gallbladder disease but the gallbladder contained a large stone. Rothenberg and Linder<sup>3</sup> state that liver abscess is rarely preceded by cholecystitis whereas Ochsner and Debaquey<sup>1</sup> found cholecystitis to be the cause in 6.3 per cent of their cases of pyogenic liver abscess but do not state whether these were solitary or multiple.

**Bacteriology.** The most common organisms found are the streptococci, staphylococci and bacilli coli. In eleven of Rothenberg and Linder's<sup>3</sup> forty-seven cases of solitary abscess of the liver the pus was sterile. Out of twenty-nine of Ochsner's and Debaquey's<sup>1</sup> forty-seven cases of both types that were studied bacteriologically eleven were sterile. Other organisms reported by Williams and co-workers,<sup>4</sup> Rothenberg and Linder,<sup>3</sup> Eliason and co-workers<sup>2</sup> St. John and co-workers,<sup>5</sup> and Ochsner and Debaquey,<sup>1</sup> are: Aerobic hemolytic streptococci, anaerobic hemolytic streptococci, non-hemolytic streptococcus aureus, non-hemolytic staphylococcus albus, Bacillus coli, pneumococcus, Bacillus subtilis, faecalis, alcaligenes, diphtheroids, mucosus capsulatus, pyocyaneus, aerogenes capsulatus, typhosus, lephthrix, streptothrix, salmonella, spirochetes and gonococci. In Case I in this report no bacteriological studies were done. In Case II beta hemolytic staphylococcus aureus was isolated and in case III the pus was sterile.

**Pathology.** Infection of the liver may take place through the following routes in order of their importance in solitary liver

abscess: Hepatic artery and vein, portal vein, bile ducts, direct extension and lymphatics.

The first four routes are the most common although the relative importance of each is difficult to determine from statistics in the literature on the subject because of multiple liver abscesses being included in the same series with the solitary type. Rothenberg and Linder<sup>3</sup> have pointed out the importance of the first and believe it is the route in those cases of undetermined origin. Suppurative appendicitis is a common cause of pyogenic abscess through the portal vein but its frequency probably has been overemphasized. Since appendicitis is more often the cause of multiple abscess formation in the liver rather than solitary abscess, statistics on the cause and pathogenesis of liver abscess which include both types are misleading.

This process occurs through thrombophlebitis of appendicial vessels with passing of infected emboli to the liver or progressive phlebitis spreading up the portal vein. Similar infection in the portal vein system can cause abscess by infected emboli. One of the patients in this report developed an abscess of the liver through the portal vein and the second abscess probably developed through an infection in the biliary system.

Ochsner and Debaquey<sup>1</sup> place infection from the gallbladder in the direct extension group as the disease process is due to biliary stasis plus infection with inflammation extending through the biliary tract or pyelephlebitis may supervene on cholangitis by extension of infection along the portal spaces via the lymphatics or the small veins of the bile ducts. This usually produces multiple abscesses involving practically the entire liver and closely resembles the classical abscesses which follow appendicitis.

A good example of this type of infection was recently reported by Williams and Ovens<sup>4</sup> in a case of multiple liver abscesses due to Bacillus pyogenes and associated with a gallbladder that was enlarged and firm and contained numerous stones. The

patient was cured with drainage of the gallbladder and cystic duct. The authors point out that the bile ducts can be drained and indirectly also the abscesses higher up by means of cystic or common duct drainage.

Non-penetrating injuries may cause abscess formation in the liver by hematoma formation with destruction of liver tissue. Penetrating injuries may result in destruction of tissue and infection of the liver.

Direct extension as from a ruptured peptic ulcer is a not uncommon cause of solitary liver abscess.

According to Rothenberg and Linder<sup>3</sup> the right lobe is involved five times more frequently than the left lobe. Serege and others as quoted by Eliason and co-workers<sup>2</sup> have shown experimentally that blood flows in the portal vein in two currents, the one on the right from the superior mesenteric vessels passes into the right lobe and the current on the left from the inferior mesenteric and splenic veins passes into the left lobe on the liver. Although Serege has been quoted by several writers on the subject, Eliason and co-workers<sup>2</sup> point out their series of fifteen cases do not confirm this. In twelve of their cases of solitary abscess of known cause and location, three left lobe abscesses arose from foci drained by the superior mesenteric vein and the three foci in the inferior mesenteric drainage led to right lobe abscesses. Of the fifteen solitary abscesses in their series, seven were located on the dome of the right lobe, four on the dome of the left lobe, one on the posterior aspect of the right lobe, one on the posterior aspect of the left lobe, one on the anterior aspect on the right lobe and the location of one was not stated. Two of the cases in this report occurred on the dome of the right lobe and the third involved the left lobe. The solitary pyogenic liver abscess is generally well walled off and when present on the dome of the liver there is usually a reaction of the diaphragm with resulting adhesions and pleurisy with or without effusion. The abscess may at times rupture into the pleural cavity or

into the lung itself provided the local reaction has been severe enough to form numerous adhesions of the parietal to the visceral pleura. In the first and second cases in this report there were numerous fine adhesions between the dome of the liver and the diaphragm. The second of the two cases developed a large pleural effusion following surgery.

*Signs and Symptoms.* Chills, fever, rapid loss of weight and strength, nausea and vomiting, and pain in the hepatic region just below the costal margin are the usual symptoms. In Rothenberg and Linder's<sup>3</sup> experience abdominal pain or symptoms referable to an intra-abdominal lesion were present in only a few of their patients. This was also noted in the second case in this series as the patient's abdominal symptoms were not marked, and were characterized by a catching pain under the right rib margin anteriorly at the onset of the illness which disappeared after a short time. The first and third cases in this report were characterized by rather severe abdominal pain, high fever and loss of strength; and in the first by pain in the right costovertebral angle. Chills with high fever were present in the first two cases. Pain in the lower right thoracic region is frequently the first symptom to draw attention to a disease process in the liver. This symptom was present in the second of the two cases reported in this paper but was never of marked prominence. Jaundice appeared late in the second case, a point noted by Ochsner and Debakey.<sup>1</sup> A septic type of temperature is commonly found and most patients have chills with profuse sweating. This was noted in two cases in this report. Two-thirds of Rothenberg and Linder's<sup>3</sup> series had chills. Various authors on the subject of pyogenic liver abscess give a higher incidence of chills probably due to the fact that most reports, as has been mentioned previously, contain both multiple and solitary pyogenic abscess and the former type generally gives a more septic course with chills and picket fence temperature curve. It is interesting to note that in Ochsner and Debakey's<sup>1</sup>



series of both types of pyogenic abscesses, the incidence of chills was only 36.1 per cent.

Pain in the shoulder on inspiration is not uncommon due to the pleural reaction and was exhibited by Case II in this report. St. John, Pulaski and Fener<sup>5</sup> in their case of solitary pyogenic abscess of the liver caused by an anaerobic nonhemolytic streptococcus noted the production of pain in the right shoulder with deep inspiration with the patient supine and the absence of the pain when the patient was in the sitting position. Tenderness just below the costal margin on the right is frequently present. Localized intercostal pain was not exhibited in these two cases.

Pulmonary signs are frequent as pointed out by Rothenberg and Linder.<sup>3</sup> Case II had dullness at the right lung base with diminished expansion of the right chest and rales probably due to compression of the lung by the liver and he was admitted to the hospital with a diagnosis of pneumonia. This case also developed a right pleural effusion late in the course of the disease. Case III had x-ray findings of diaphragmatic pleural irritation with slight effusion. The diagnosis of pneumonia with treatment for this condition is not uncommon before the real nature of the disease process is discovered.

In Case I the white blood count was 25,000 with 88 per cent polymorphonuclears, in Case II the white blood count was 11,400 with 74 per cent segments on admission and rose to 18,000 with 89 per cent segments just before surgery eleven days after admission and in Case III the white blood count was 17,000 with 86 per cent neutrophils.

The laboratory findings are those of a suppurative process in the body with leukocytosis and not infrequently albumin in the urine. The leukocytosis is as a rule not as high as that found in multiple abscesses but is higher than an uncomplicated amebic abscess.

The spleen is at times palpable as was the case in the second in this report. The liver is often not palpable and the extent of

liver enlargement upward is often difficult to determine on physical examination. In Rothenberg's and Linder's<sup>3</sup> series 74 per cent had palpable livers. In neither of the first two cases reported in this paper was the liver palpable and in the third a questionable mass was present which later proved to be the left lobe of the liver.

The x-ray findings are important and reveal an elevated diaphragm on the right. Fluoroscopy usually reveals a partially immobile diaphragm with limited excursions. In Rothenberg's and Linder's series one third of the cases showed an elevated and fixed diaphragm. Gessner<sup>6</sup> pointed out that 72 per cent of a series of ninety-six cases of amebic abscess of the liver showed a high right leaf of the diaphragm. In Ochsner's and Debaquey's<sup>1</sup> series of forty-seven cases of both types of pyogenic abscess of the liver, the x-ray diagnosis was positive in 82.1 per cent. The case reported by St. John and co-workers<sup>5</sup> showed only diminished mobility of the right diaphragm on fluoroscopy and no enlargement of the liver on x-ray. Eliason, Brown and Anderson<sup>2</sup> in their series of both types of pyogenic liver abscess obtained only 64 per cent positive x-ray findings. All three cases in this report showed elevation of the right diaphragm with limited excursion on fluoroscopy.

**Diagnosis.** The onset of solitary liver abscess is often insidious and the source is frequently impossible to determine in contrast to multiple liver abscesses in which the onset is usually sudden and acute and the source of infection is more likely to be obvious. The history of chills, fever, vague pain in the hepatic region at times associated with pain in the right shoulder, elevated leukocyte count, x-ray and fluoroscopic findings of an elevated right diaphragm with enlarged liver shadow and diminished movement of the diaphragm should make one suspect liver abscess of the solitary variety.

Rothenberg and Linder<sup>3</sup> have shown that nausea and vomiting is an important aid in diagnosis as these symptoms are infrequent in solitary liver abscess whereas in

cholecystitis, pancreatitis, intestinal obstruction, ruptured ulcer and other conditions accompanied by peritoneal irritation, nausea and vomiting are often marked. In the presence of multiple liver abscesses the temperature is higher and more of a septic type of fever with chills being more frequent. Palpable liver enlargement and jaundice are more frequent in multiple liver abscesses.

The onset of amebic liver abscess is insidious and the fever is not as a rule high unless secondary infection has taken place. Aynesworth<sup>7</sup> reported three cases of amebic liver abscess of twelve, nine, and five years durations with low grade fever during this time and a history of chronic invalidism. The patient with an amebic abscess is not as sick as the patient with a pyogenic abscess. The history of diarrhea and the finding of the endameba histolytica in the stools will aid in the diagnosis of amebic abscess.

Subphrenic abscess is more likely to have antecedent infection such as a ruptured appendix. The pain of a subphrenic abscess is often more severe than that in a liver abscess, the liver is not enlarged and costo-vertebral tenderness is more likely to be present in this condition. Fluoroscopy is likely to reveal more fixation of the diaphragm than in the case of the liver abscess.

Ochsner and Debaquey<sup>1</sup> advise against exploratory aspiration of the liver for pus and state that it is a dangerous and unjustifiable procedure. Herrick, quoted by Gessner,<sup>6</sup> with a considerable experience in the Canal Zone with amebic abscess of the liver describes localization by needle as unreliable and speaks of fatalities reported from its use.

*Prognosis.* The prognosis in solitary pyogenic liver abscess depends on the presence or absence of complications, general condition of the patient, the type of treatment with regard to drainage and the location of the abscess.

In Ochsner's and Debaquey's<sup>1</sup> series their mortality in the solitary liver abscesses was 37.5 per cent, Eliason and co-workers<sup>2</sup>

reported a mortality of 60 per cent in ten cases of solitary pyogenic liver abscess operated, and Rothenberg and Linder<sup>3</sup> obtained recoveries in 58.3 per cent of all their cases of solitary pyogenic liver abscess.

Cases 1, 11 and 111 in this report recovered.

*Complications.* The most frequent complication of solitary pyogenic liver abscess is involvement of the pleura or lungs. The most common site of the solitary abscess is on the dome of the right lobe of the liver, hence the diaphragm on the right early becomes involved as the abscess cavity pushes upward. Adhesions develop soon and pleurisy with effusion, empyema, or rupture into the lung itself have been reported. Cases 1 and 11 in this report had adhesions between the diaphragm and the right lobe of the liver and the second case had a large pleural effusion. The third case exhibited x-ray findings of diaphragmatic pleurisy with effusion in the costophrenic angles.

Peritonitis as a complication usually results from spilling of pus into the peritoneal cavity while performing transperitoneal drainage.

*Treatment.* The treatment of pyogenic liver abscess is incision and drainage through a transpleural or transabdominal approach. The transpleural method was first suggested by Trendelenburg in 1883, according to Ochsner and Debaquey<sup>1</sup> and later modified into a two stage procedure by Beck. These authors divide the operative procedures into transthoracic and transabdominal either through a transserous or an extraserous approach. In their series nine cases with transpleural drainage had a mortality of 66.6 per cent, and with the extraserous retroperitoneal approach of Ochsner and Nather in six cases there was a mortality of 33.3 per cent. In twenty-two cases in which the transperitoneal method was used the mortality was 72.7 per cent.

In performing the transabdominal approach it is important to carry out the operation in stages so as to allow adequate formation of adhesion before opening the abscess. After making the incision,

which is adequate with a paracostal incision, the wound should be packed with vaseline gauze and the wound reopened several days later and the abscess then drained, provided there are adequate adhesions. Ochsner and Debakey<sup>1</sup> point out that the method of Clairmont for drainage of subphrenic abscess may be used. This consists of a paracostal incision and incision down to the parietal peritoneum and then mobilization of the parietal peritoneum from the lower surface of the diaphragm up to the abscess.

In the first of the author's case, the abscess was in the mid-portion of the dome of the right lobe and was approached through the abdomen using a paracostal incision. Drains were placed in the wound in an attempt to form adhesions and wall off the disease process.

In the second case while waiting for adequate adhesions to wall off the disease process, penicillin was given intramuscularly and also injected into the abscess following aspiration. Subsequent surgery several days later revealed the abscess cavity to contain only a few cc. of bloody serous fluid.

In the third case the abscess in the left lobe of the liver was already walled off by adhesions at the time of surgery.

Therefore, it would seem that penicillin is a potent weapon against the solitary liver abscess when due to the staphylococcus or streptococcus. When operated by either the transpleural or transabdominal approach, penicillin injected into the cavity of the abscess plus systemic use may sterilize the abscess and lessen the dangers of contamination provided a second stage procedure is to be carried out. The technique of Noth and Hirshfeld<sup>8</sup> may prove to be of value in pyogenic liver abscess. These authors treated a case of amebic abscess of the liver by inserting penicillin into the cavity daily. This procedure might be carried out through a transpleural or transabdominal approach while waiting for adhesions to form. This method might make a second stage unnecessary or if the second stage is needed, the abscess may be

sterile as was evidently the case in our second patient. Aspiration and injection of penicillin into such abscesses may prove to be a more satisfactory method of treatment in the future by eliminating the extensive sloughing of liver tissue that is seen at times following incision and drainage of a liver abscess.

Another important point is the marked improvement in the general condition of Case 11 following the second stage at which time the abscess was aspirated and the cavity filled with penicillin. The patient was out of bed four days after the second operation was performed and he was out of bed ambulatory on the second day following the third operation, at which time the abscess was opened.

#### SUMMARY

1. Three cases of solitary pyogenic abscess of the liver are presented.
2. A brief discussion of solitary pyogenic liver abscess is given.
3. Penicillin is a potent weapon in the treatment of the solitary pyogenic liver abscess especially when adequate drainage is carried out.
4. Aspiration of solitary pyogenic abscess of the liver and injection of penicillin may prove to be a satisfactory method of therapy.

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# CARCINOMA OF THE BREAST FOLLOWING BURN\*

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THE direct relationship of burns to cancer of the skin is well recognized and generally accepted. Of the numerous reports of cancer of the skin developing in scars of burns, the largest single series of cases has been reported by Treves and Pack.<sup>1</sup> Over a twelve-year period they found twenty-one epidermoid carcinomas and seven basal cell carcinomas growing in the site of previous burns. These cases constituted 1.1 per cent of all the carcinomas of the skin seen. It is true that cancer of the skin may arise in scars produced by other causes, but about 33 per cent of all scars giving rise to a carcinoma are produced by burns.<sup>2</sup> Schrek<sup>3</sup> reported five basal cell carcinomas and seven epidermoid carcinomas developing from scars of different origins (roentgen ray burns, burns, lacerations, surgical operations and ulcerations). They constituted 2.8 per cent of his total number of cases. But of sixty which developed on the scalp, trunk, arms and legs, eleven (or 18 per cent) developed in scars. It is evident from these figures that the proportion of carcinomas of the skin arising from scars is twenty-five times greater on the scalp, trunk and extremities than on the face and neck, where carcinomas from other causes are more common. On the extremities alone, carcinomas developing in the scars of burns make up between 9 per cent and 25 per cent of all cases of carcinoma.<sup>2</sup> Consequently it may be concluded that the appearance of carcinoma in an area where carcinoma is rarely encountered is not purely fortuitous but is certainly related to pre-existing changes induced by heat or some other agent.

As a general rule it takes a long time for a carcinoma to develop in a burn scar. Treves and Pack<sup>1</sup> reported an average interval of 32.5 years, and Pack and Livingston<sup>4</sup> found

an average interval of 19 years. There is frequently a history of delayed healing, recurrent setbacks and ulceration. Pack and Livingston recorded an average of 800 days from the time of the burn to complete healing. The cases had been permitted to granulate and skin grafting was not employed. The systematic grafting of burns should diminish the number of these lesions which degenerate into carcinoma.<sup>1,4</sup> Treves and Pack<sup>1</sup> reported six cases of so-called acute burn-scar cancer which developed within several weeks to a few months following the burn and before the skin had completely healed. This type of carcinoma usually appears in older people with atrophic, keratotic skin. Such preparatory skin changes apparently increase the susceptibility of the skin to develop carcinoma following even a superficial burn.<sup>5</sup> On the other hand, in the chronic burn-scar carcinoma in which there is a long interval following the burn before the appearance of neoplasia, the age of the patient is of no importance; it is rather the age of the scar which is of importance in the development of carcinoma.<sup>1,3,6,7</sup>

The cancers developing in a scar have a rather slow rate of growth and usually metastasize late. Histologically, these lesions show the same characteristics of other skin carcinomas but have an extremely dense, fibrotic stroma. When the tumor invades the normal skin, it seems to parallel if not surpass the rate of development of ordinary carcinomas of the skin,<sup>1,6,7</sup> and distant metastases are often present.

Radiotherapy is seldom successful in the treatment of carcinomas arising from scars, because the scarred tissues will not stand the quantity of radiation required for the sterilization of the tumor. Attempts to

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treat these lesions by radiotherapy result in wide areas of necrosis.<sup>1,2,4,6,10</sup> The recommended form of treatment is radical surgical excision and skin graft, followed by regional lymph node dissection when indicated.<sup>11</sup>

The development of carcinoma following thermal injury has not been reported in organs other than the skin and connective tissue. A case of transition of a pigmented nevus into a malignant melanoma following a burn,<sup>1</sup> and another of neurogenic sarcoma in a burn scar in a patient with generalized neurofibromatosis, have been cited. There have also been two cases of fibrosarcoma appearing in old burn scars.<sup>12,13</sup> To our knowledge, there have been no cases of tumor arising from muscle, fat or bone within the area of a deep thermic burn.

The two cases presented here represent adenocarcinomas of the breast in which an etiologic relationship to a previous burn is strongly suspected. Admittedly, this suspicion could be mere coincidence, but one must bear in mind that the breast is, of all glandular structures close to the skin, the most susceptible to the development of carcinomas. This report may help to bring to light other such cases which may not have been published because of the belief that this was indeed mere coincidence.

#### CASE REPORTS

**CASE I.** A. S., E.F.S.C.H. No. 43-5107. A thirty-six-year old white woman entered the hospital in March, 1943, complaining of a mass in the left breast. Seven years before, the breast had been burned by exposure to steam. This was followed by intermittent healing and recurrent ulceration, but the treatment did not include skin grafting. Two years before admission, a mass developed beneath the ulcerated area, and from that time on there had been persistent ulceration with increase in the size of both the ulceration and the tumor mass. In addition, there had been a weight loss of twenty-five pounds during the past year.

On examination, the patient was a red haired, well developed, well nourished, white woman showing evidence of weight loss. There was a large mass in the left breast directly underlying

an 8 cm. necrotic ulceration, with obvious skin retraction and edema about the ulceration. (Fig. 1.) An enlarged, firm, movable node was palpable in the left axilla; but the opposite breast and axilla, and both supraclavicular areas were apparently normal.

Laboratory data revealed only an elevated white blood count of 15,700. Skeletal roentgenograms showed no evidence of osseous metastases, but the roentgenogram of the chest disclosed extensive pulmonary metastases. Biopsy of the ulcer bed showed a moderately well differentiated carcinoma, obviously of duct origin, with associated infection and a variable amount of connective tissue stroma. (Fig. 2.) Palliative radiotherapy was directed to the breast and the patient was discharged. She expired August 1, 1943.

**Summary.** This case represents a carcinoma of the breast occurring in a young woman, following a severe burn. The clinical course is similar in many respects to that found with carcinoma growing in the scar of a burn. Healing by granulation and recurrent ulceration followed a burn of the breast, and after five years, a mass was observed. At examination two years later, the mass was found directly beneath a necrotic ulceration of the skin. A biopsy revealed adenocarcinoma of the breast. Axillary and pulmonary metastases were present, indicating a rather rapidly progressing disease.

**CASE II.** H. C., E.F.S.C.H. No. 44-6565. A fifty-five-year old white woman entered the hospital on July 14, 1944, with a mass in the right breast. At the age of two, there had been a severe hot-water burn involving this region. The nipple was destroyed at that time and subsequent slough of skin and underlying tissue exposed the ribs. Skin grafting was not undertaken and healing resulted in extensive scar formation. Eight months before admission, a small lump appeared in the right breast and was thought to be scar tissue. However, three months before admission there was reddening of the skin with a burning sensation, and subsequent growth of the mass was accelerated, slowly at first but more rapidly later. Six years before admission, an abdominal hysterectomy and unilateral salpingo-oophorectomy had been

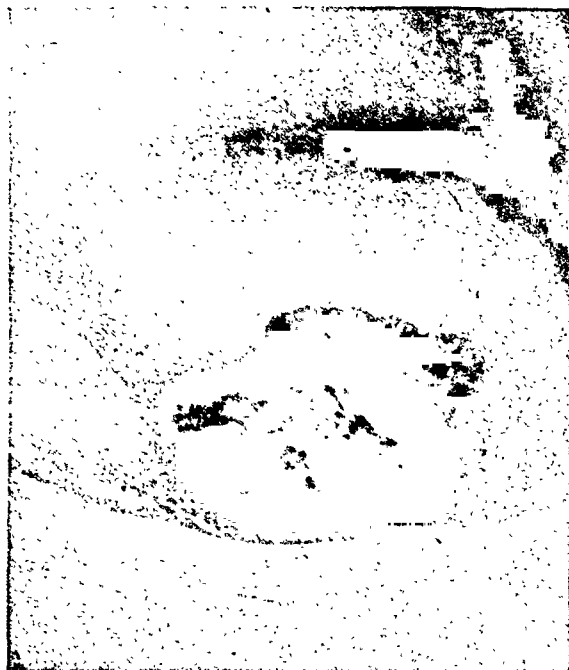


FIG. 1. Case 1. Prominent ulceration of breast with nipple destruction.

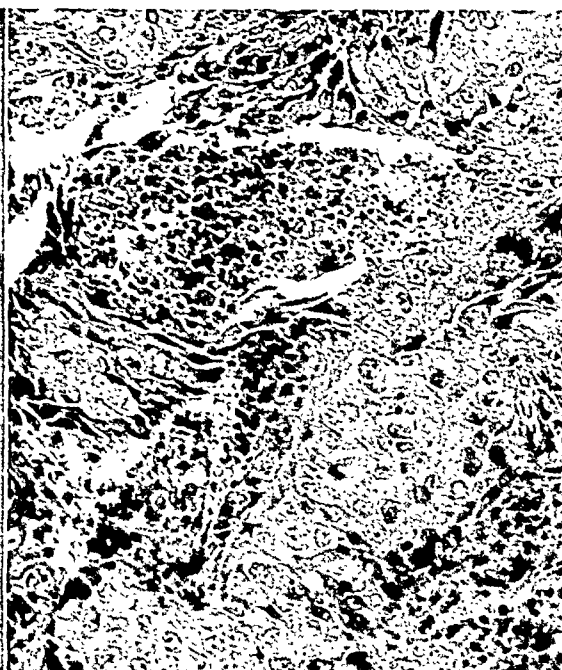


FIG. 2. Case 1. Photomicrograph (high power); typical carcinoma with infection.

performed, with the removal of a six-pound tumor of the uterus.

On examination, the patient was an obese, white female who presented an old scar over the mid-portion of the right breast, with absence of the areola and nipple. Directly underlying the area of greatest scarring there was a firm, non-tender mass measuring 8 by 10 cm., attached to the skin but freely movable over the underlying fascia. In the central portion of this mass just beneath the skin, there was a 2.5 cm. area of fluctuation. Palpable lymphadenopathy was not present in either axilla or in the supraclavicular regions.

Laboratory data were within normal limits and a roentgenogram of the chest showed no evidence of pulmonary metastases.

On the fourth hospital day, aspiration biopsy of the fluctuant area of the tumor mass yielded 45 cc. of amber, slightly bloody fluid. No pathologic diagnosis could be made on this specimen. Three days later a radical mastectomy was carried out. The gross specimen consisted of the right breast, pectoral muscles and axillary contents. The attached skin showed scarring and thickening. There was a large tumor mass in the breast measuring 11 cm. in its greatest diameter and extending to a depth of 8 cm. below the skin. In the central portion of this tumor just beneath the skin there was a cystic area measuring 6 by 4 by 3 cm., containing a reddish-brown clot.

(Fig. 3.) Sections taken through the tumor showed a rather well differentiated breast carcinoma arising from duct epithelium. (Fig. 4.) The stroma showed a marked fibrosis with areas of chronic inflammation. The remainder of the breast tissue was atrophic. Sections through the skin revealed thickening of the epidermis, a reduction in the number and height of the papillae, and a diminution to absence of skin appendages. (Fig. 5.) A marked fibrosis of the subcutaneous tissue extended into the breast parenchyma as well. There was no evidence of carcinoma in the axillary nodes.

The postoperative course was uneventful, and the patient was discharged on August 7, 1944. At the last clinic visit, sixteen months after discharge, there was no evidence of local recurrence or spread of the disease.

*Summary.* At the age of two, this patient suffered a severe burn of the region of the right breast which destroyed the nipple and surrounding soft tissue of the breast. Healing occurred by scar formation and further ulceration did not develop. Fifty-two years later a mass appeared in this breast directly beneath the area of greatest scarring. A radical mastectomy was performed and examination of the specimen showed a typical adenocarcinoma of the breast growing in a fibrotic parenchyma.

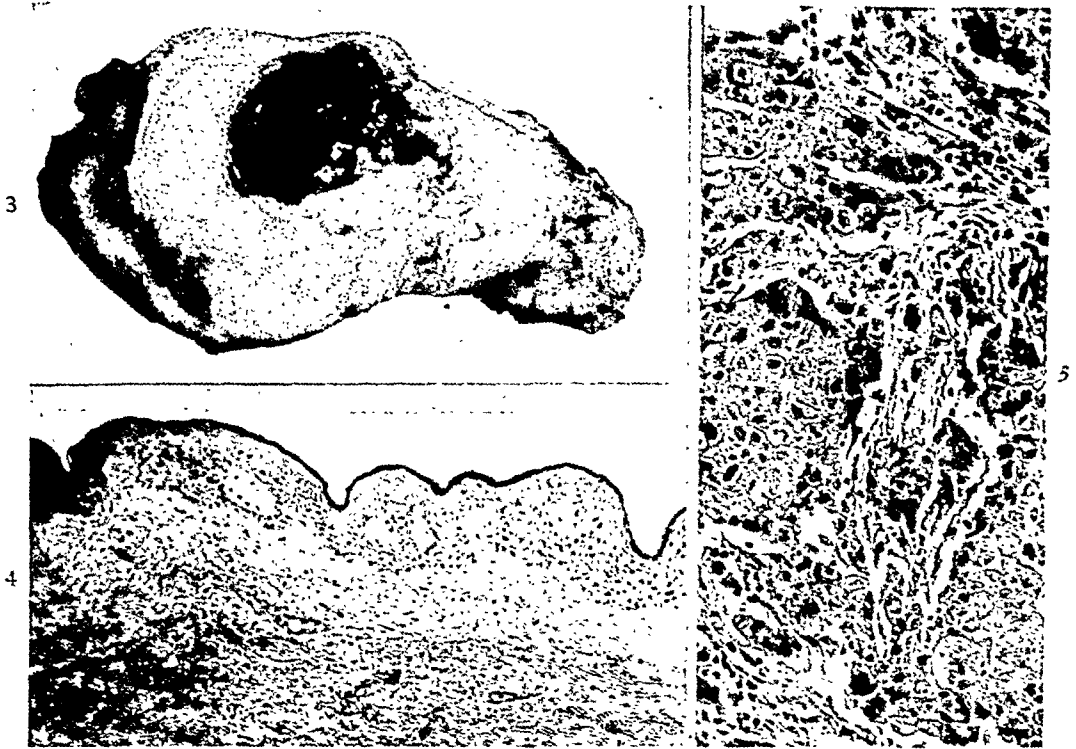


FIG. 3. Case 11. Transection of surgical specimen showing large cystic carcinoma.

FIG. 4. Case 11. Photomicrograph (high power); typical carcinoma.

FIG. 5. Case 11. Photomicrograph (low power); skin in the area of the scar. Note atrophy, fibrosis and absence of skin appendages.

The carcinoma extended deeply into the breast but did not invade pectoral muscles. There was fibrosis in the normal breast parenchyma as well as in the areas of neoplasia.

#### COMMENT

The sequence of events in both of these cases of breast cancer had a similar pattern. A severe burn, untreated by skin grafting was followed by extensive scarring in both and by chronic ulceration in one. After a long time interval, carcinoma developed in the areas of greatest alteration of the breast. While it cannot be proven that the development of cancer was not a mere coincidence, the sequence of events strongly suggests that there was some etiologic relationship between the development of carcinoma and the earlier burn.

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# TUBERCULOUS SALPINGITIS

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SINCE the publication of Hegar's work in 1886, genital tuberculosis and its protean manifestations have stimulated the interest of gynecologists throughout the world. It was unusual to have a Clinical Congress of Surgery in Paris or Berlin during the early twentieth century without frequent references to this infection, its pathogenesis, probable mode of entry and treatment.

## ETIOLOGY

The etiology of genital tuberculosis, whether primary or secondary and its relationship to tuberculous involvement of the peritoneum are matters which still remain in high dispute among pathologists and clinicians. It is generally regarded probable that tuberculosis of the internal generative organs is secondary to an infection of similar etiology elsewhere in the body, the lungs being the commonest source. Only in those very unusual cases limited to the vagina, cervix or vulva is it conceivable that the process may be a primary one from direct contact with contaminated instruments or from intercourse with an individual having a discharging tuberculous lesion of the genitourinary tract. For practical purposes, genital tuberculosis is a disease of the internal reproductive apparatus, and the Fallopian tubes are involved in almost every instance, (although tubercles may be grossly absent), hence a discussion of genital tuberculosis connotes a condition of tuberculous salpingitis. Other pelvic organs are slightly less immune; the uterus is involved in about 65 per cent; the ovaries in about 30 per cent, and the cervix in about 5 per cent of all cases. This decreasing frequency is in contrast with the tissue response to an acute gonorrheal infection in which the urethra,

Bartholin's glands and vagina show early pathologic change, followed by late secondary salpingo-ophoritis.

In a patient with chronic gonorrheal salpingitis and no history of early characteristic symptoms, the differentiation from pelvic tuberculosis may be quite difficult in the absence of a primary tuberculous focus (lungs-bones).

The relationship of specific tuberculous peritonitis to tuberculous salpingitis clouds the clinical picture further because the occurrence is almost reciprocal, i.e., the peritoneum is involved in more than half of the cases of genital tuberculosis, while in a group composed of patients with primary diffuse peritoneal granulomas, the Fallopian tubes were infected in 44 per cent. When both tubes and peritoneum are diseased there may be no way, even at operation definitely to separate the primary from the secondary process.

Tuberculous salpingitis is seen most often among young adults between the ages of eighteen and thirty-five although its occurrence in infants and in women past the menopause has been occasionally observed. In the French literature the designation of "*ascite des jeunes filles*" indicates the frequency of this infection during adolescence.

Pathologic changes stimulated by the tubercle bacillus may develop either in the endosalpinx or on the peritoneal covering of the tube. In the first type, the infection is a true salpingitis starting in the mucous membrane of the ampulla and spreading by continuity throughout the deep layers of the tube. The peritoneum itself may show no evidence of involvement. Pyosalpinx, sterility and tuberculous uterine endometritis are very common. In the second type, both tubes



show the evidences of a diffuse tuberculous peritonitis which almost invariably infects the pelvic serosa together with that of the small and large intestine. The gross appearance at laparotomy is that of multiple, widely disseminated tubercles studding the visceral peritoneal surfaces. The process may be predominantly ascitic; or fibroblastic with extensive, dense adhesions between contiguous organs; or caseous with necrosis, ulceration, internal sinus formation and a severe systemic toxemia.

#### SYMPTOMS

The symptoms of pelvic tuberculosis are often quite bizarre. If the bacillary virulence is great and the host's resistance low, there will result a rapid overwhelming toxemia. This is augmented by secondary pyogenic invasion of the multiple fistulas which develop between involved abdominal contents and the vagina, rectum, bladder and skin. The prognosis in such a patient is unfavorable, and it is mainly this group which accounts for the 20 per cent mortality associated with the disease. Less severe infections may resemble malaria with recurring moderate fever, lassitude, anorexia and a remarkably complete absence of noteworthy abdominal or pelvic complaints.

Salpingitis in a young virgin should be considered tuberculous unless definitely ascribable to a different cause. Menstrual irregularities varying from profuse menorrhagia to amenorrhoea with or without intermenstrual spotting may occur. Dysmenorrhoea is very common. A pelvic infection recalcitrant to adequate treatment probably is tuberculous in origin especially if no evidence of gonorrhea can be found. Many etiologically enigmatic cases of sterility will be found to harbor a bilateral tuberculous process in the endosalpinx, with cicatricial obliteration of both tubal lumina.

#### DIAGNOSIS

The correct diagnosis can easily be made preoperatively in some patients;

it may be impossible even at laparotomy in others. A history of chronic menstrual irregularities in a barren woman with uterine hypoplasia, bilateral adnexal masses and a pulmonary tuberculous focus is highly suggestive. Conversely, salpingectomy is frequently performed for nodular chronically infected tubes with no suspicion that a specific granuloma exists and the microscopic sections furnish the initial and perhaps only clue to its actual tuberculous etiology. In a large university series a correct preoperative diagnosis was made in 13 per cent of an unselected group composed of various pelvic inflammatory diseases. An accurate history together with a meticulous physical examination, evaluating both negative and positive findings is essential if a high degree of correct preoperative diagnoses is desired.

#### TREATMENT

The treatment will depend on the extent and distribution of the tuberculous process. Total removal of all infected tissue, when possible, affords the best chance for complete recovery. Technical difficulties may, however, prevent radical extirpation, particularly in the extensive fibroblastic and caseous types of visceroperitoneal involvement. Because of their predilection to this condition, the Fallopian tubes should, whenever feasible, be isolated and carefully examined in every patient with genital tuberculosis coming to operation. If involved, complete bilateral salpingectomy with cornual excision to remove the interstitial portions of each tube is desirable. Opinion varies somewhat regarding the disposition of ovarian tissue in the younger patient group. The preservation of normal endocrine physiology is certainly important, but I believe less so than the thorough eradication of all tissue showing gross contamination. It will be recalled that ovarian infection is present in only one of every three patients with tuberculous salpingitis. Potential ovarian conservation is therefore

a good mathematical probability, but when evidence of oophoritis exists, they should be removed without compunction. In the case history presented below, the menses were unexpectedly resumed despite what was thought to be a very complete tubo-ovarian resection. Frequent mention has been made in the literature regarding the beneficial effects which attend the laparotomy and the exposure of infected organs to atmospheric oxygen. Just what this procedure may accomplish is illustrated by the following clinical report:

#### CASE REPORT

On March 25, 1944, a sixteen-year old girl of Polish extraction came to my office with the following history. About two years ago, she became involved in a white slave ring and for six months was forced to engage in extensive commercial prostitution in a Texas border town. In September, 1942, she escaped and returned home. Because of her experiences and the likelihood of having contracted syphilis, the patient reported to the local venereal disease clinic where repeated Kahn tests proved negative. A dark-field examination, however, performed in the southwest, indicated the presence of spirochete pallida. Cervical specimens failed to demonstrate gonococci, but trichomonas vaginalis infestation was profusely evident in each smear. A course of bismuth and mapharsen was administered under very competent supervision at the clinic. After about four months, the patient failed to return for treatment, stating that she was under the care of a private physician. During this period and for the ensuing six months she enjoyed excellent health; had no systemic complaints, and worked regularly as an apprentice model in a large St. Louis department store. Menses were normal and painless.

On July 4, 1943, while returning from an Independence Day celebration, she experienced a sudden profuse metrorrhagia which lasted about five hours. The cessation of bleeding was succeeded by a fever of 103°F. and slight nausea but no vomiting or abdominal pain. A physician was called who advised immediate hospitalization, and on July 12th a midline laparotomy was performed under procaine spinal anesthesia. Tentative diagnosis was acute appendicitis. On opening the peritoneum

literally hundreds of miliary tubercles were visible on the exposed intestinal surfaces. Extensive caseation with organized fibrinous exudate was present throughout the peritoneal cavity. The gross appearance seemed so hopeless that no detailed pelvic examination was performed. The incision was closed without drainage after insufflation of 100 per cent oxygen. No organs were removed. The surgeon's impression was advanced tuberculous peritonitis. The patient was discharged from the hospital in two weeks; the prognosis was unfavorable. For about one month she was relatively free of symptoms, following which she became aware of an increasing sense of discomfort in the operative region. Shortly afterward there was a sudden exacerbation of the local pain coinciding with the appearance of a blueish, thin-walled tumefaction in the abdominal incision. This was surgically drained leaving a small discharging sinus. For nine months treatment consisted of frequent probing and dressings with no improvement in the condition, which persisted as a tract discharging moderate quantities of a thin, milky, odorless exudate.

It was at this time that she consulted me. Examination revealed a well developed female appearing to be about twenty years old. Her stated age was sixteen. She was 5 feet 9 inches tall and weighed 142 pounds, blood pressure was 114/68, pulse 86/min. and temperature was 99.6°F. The pupils were regular and reacted actively to light and accommodation. Her teeth were excellent, tonsils small with moderate anterior cervical lymphadenopathy. The heart and great vessels appeared normal on auscultation. The breasts were small, pendulous and symmetrical. An especially detailed examination of the lung fields (in view of the history) revealed no pathologic signs. The liver edge and spleen were not palpable. The rectus musculature was well developed. The previous operation left a broad infraumbilical midline cicatrix which contained a granulomatous discharging papule. A sterile probe introduced here penetrated for its full length into the peritoneal cavity without meeting any obstruction. Deep external abdominal palpation failed to elicit even mild subjective tenderness. Vaginal examination disclosed a clean mucosa and cervix. Bartholin's glands were small and Sanger's "gonorrhoeal macules" were absent. The urethra appeared normal; no

exudate was expressed on stripping the para-urethral glands. Bimanually, the uterus was small, even hypoplastic and rather firmly fixed in midposition. On each side there was a distinctly enlarged tubo-ovarian mass which merged indefinitely into the thickened broad ligament. Compression of these masses produced only slight discomfort.

In view of the intractable nature of the fistula despite competent treatment, I advised reoperation and removal of the tract together with its internal communication if possible. It was my opinion at this time that the generalized tuberculous process previously observed had subsided and that there remained a genital tuberculosis with sinus formation.

The patient was admitted to St. Elizabeth Hospital May 29, 1944. X-ray examination of the chest was normal. The sedimentation time was fifty minutes for 18 mm. (Linzenmeyer) suggesting the absence of an acute process. Temperature on admission was 99°F., red blood cells 4.55 m hemoglobin 75 per cent, white blood cell 8,700, stabs 10, segmenters 64 per cent, lymphocytes 17 per cent and mononuclears 9 per cent. Urinalysis and Kahn test were negative.

On May 30th, under spinal anesthesia, the previous operative scar was excised, removing a block of tissue consisting of skin, fascia, necrotic rectus muscle and sinus tract. On opening the peritoneum there was remarkably little evidence of the extensive pathologic change observed ten months earlier. Aside from several filmy adhesions immediately subjacent to the incision, all positive findings involved the pelvic organs. After severing a

broad rectouterine fibrinous band, the fundus and two large tubo-ovarian abscesses were easily delivered. The tract which had been carefully isolated was seen to have three internal connections, one to each of the adnexal masses, and a third to a small sub-peritoneal lymph gland in the vesicouterine space. The adnexal masses were clamped and excised together with the entire sinus tract and the infected gland. Peritonealization was effected with No. 60 cotton and the incision closed in layers with interrupted sutures of the same material.

The postoperative course was uneventful and the patient left the hospital on June 5th, six days following operation. The incision healed completely by primary union. Regular menstrual periods were established two months later, a most unexpected and welcome phenomenon. The patient, now eighteen, weighs 178 pounds and enjoys excellent health. Microscopic sections were reported by the pathologist as showing, "low grade inflammatory process involving all tissues received. There are giant cells of the Langhans' type, a fairly definite tubercle formation and other characteristics of tuberculosis. Diagnosis: Tuberculosis salpingitis."

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# New Instrument

## BOX OPERATING TABLE\*

### A SIMPLE DEVICE FOR INFANTS

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AND

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IN abdominal operations upon infants the standard operating table has been found unsatisfactory. Designed to ac-

commodate the adult, it affords no means of keeping the infant warm.

The author set about to eliminate these

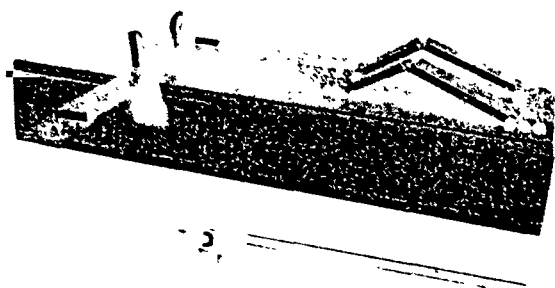


FIG. 1. Box operating table in position on regular operating table.

commodate the adult, it is difficult of adaptation to the infant. It makes no allowance for the normally flexed position of the infant knee. It makes restraint of the baby difficult. It does not lend itself with ease to the change from the horizontal to the Trendelenburg position. During the

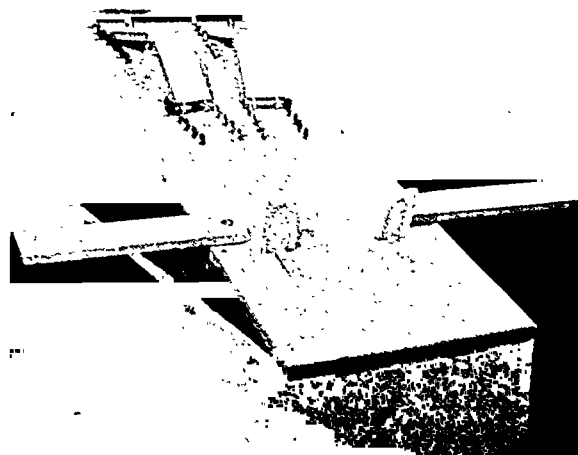


FIG. 3. Table with movable leaf in Trendelenburg position.

drawbacks by designing an operating table for infants.

The accompanying photographs and diagrams indicate the general construction of the box operating table. It is very simple, consisting of a rectangular wooden box, open at one end, with a top which may be slanted to one of two fixed angles. The box operating table, when placed on top of the regular operating table, can be adjusted to a convenient height for the surgeon when he is operating.

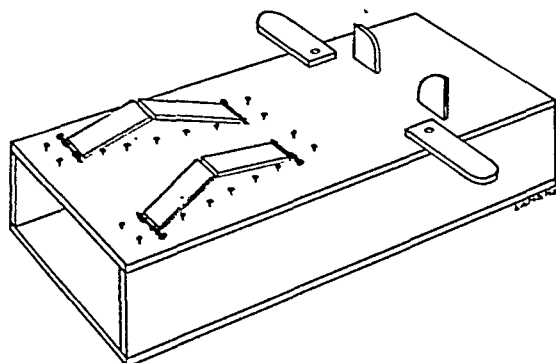


FIG. 2. Exterior design of table.

\* From the Department of Surgery, Long Island College of Medicine and the College Surgical Service, Kings County Hospital, Brooklyn, New York.

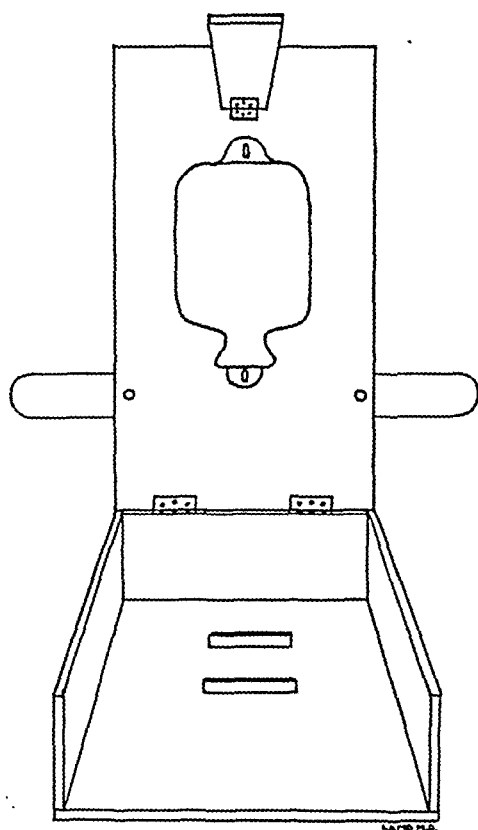


FIG. 4. Interior design of table.

The box operating table is designed to insure not only comfort to the child but also a maximal degree of restraint. It provides arm boards, shoulder rests, leg boards, a heating unit and a means of placing the patient in two different degrees of Trendelenburg. In order to preserve the normal amount of flexion of the child's knees, the leg boards are adjustable at the knees. The straight-leg position may also be had when needed, as for instance, in an inguinal herniotomy. The leg boards may be adjusted in their

distance from the shoulder rests so as to accommodate infants of varying lengths. The table is padded with soft material such as cotton or felt. The heating unit consists of a hot water bag which is buttoned to the undersurface of the movable leaf of the table.

The original model, which is now in use at Kings County Hospital, Brooklyn, is constructed of birch wood. The necessary metal parts are easily obtained. It seems to be a useful adjunct in the carrying out of surgical procedures on infants.



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## Editorial

### ON THE SHELF

ACCORDING to some of the poets old age is a wonderful time of life. We read of the shadows deepening, the tranquil hours of ease and contemplation, of a philosophy almost attained. Somewhere we read that to youth the fields of love, to man the battleground and to old age a chair in the sunshine and dreams. Unless one lives in a fog and forgets to button his clothes, all this about old age is pure bunk. If a man has his mental faculties, even though a little unsteady on his pins, he is not old. We have known old men at fifty and young men at eighty.

The majority of hospitals and most medical colleges have an age limit and retire their staff men and teachers at that age, willy-nilly. Usually when a man, because he just *must* be decrepid and mentally worn out at sixty-three or sixty-five years is put on the shelf. When he reaches the age of retirement, should he be a minor cog in the wheel, he is let out without fanfare and trumpets. Sometimes he is given certain "courtesies" if a hospital staff man. If a professor and director of the department or a president of the medical board, he may be tendered a dinner at which he sits in a sort of solitude on the dais. A toastmaster sings the victim's virtues and presents him

with an inscribed watch or a sterling tea service. Those assembled sing "For He's a Jolly Good Fellow" and wonder who is going to get the place he's left vacant.

Probably, by and large, retiring a man when he reaches a certain age is sound sense. It has been said of those in high places that few die and none resign, and the only way for someone from below to get to the top is by the age limit law. Yes, all in all, a good law. But must all who are retired be put on the shelf? When a man reaches the middle sixties, does he suddenly become mentally sterile and change over night? If one wishes to retire and follow avocations in distant fields, that is his affair; but if his heart and soul is still wrapped up in what has been his life work, is there not a place for him to continue exercising his talents and exerting his beneficial influence? In some medical schools these men, usually inspiring teachers, give a series of lectures through the year. Often they are permitted to talk or lecture on any topic of their choosing. Invariably they "play" to packed houses. Many institutions arrange for these lectures to be given to the entire student body. In some places a teacher widely known in a field of medicine gives a course of formal lectures on his specialty within a specialty.

We bring this up because of a gentleman who was retired. He hinted he would like to carry on even in a minor capacity, but the lay board of directors voted otherwise. Now he is lost. He putters in a laboratory and makes notes for another book he probably will never write.

Imagine John Erdman, Hubert Royster or the late Frederick Holden being told they were washed up and ready for the shelf when they had reached the old age of sixty-five years! And what title is more hollow than that of Emeritus?

T. S. W.



THE American Book Center for War Devastated Libraries appealed last year to scientific publications for scholarly printed materials for shipment to the profession overseas. The responses to such appeals as this have been most encouraging and have made it possible for the American Book Center to provide at least a part of the information on which physical and cultural reconstruction programs must be based.

The very great need made apparent by hundreds of requests from Europe and the Orient for additional books and periodicals has caused the Board of Directors of the American Book Center to extend the life of this agency through 1947. Therefore, we are calling upon our readers to contribute the printed materials which are needed.

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# Original Articles

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## POSTOPERATIVE PULMONARY ATELECTASIS\*

MAJOR ALFRED L. KRUGER,  
Chief, Respiratory Disease Section

MAJOR PHILLIP S. MARCUS  
Chief, Anesthesia Section

AND

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**A**TELECTASIS occurring as it does after any surgical procedure, irrespective of the type of anesthesia used, must receive the serious consideration of surgeon, internist and roentgenologist alike. Atelectasis is a serious postoperative complication in itself and in addition its secondary complications, pneumonia and bronchiectasis, increase the importance of preventing this condition and vigorously combating it, once it appears.

In the interval between March, 1942 and November, 1945, 6,553 major surgical procedures were performed at the AAF Regional Hospital, Keesler Field, Mississippi. This total does not include those patients operated upon under local anesthesia. Spinal anesthesia was used in 62 per cent of the patients; the remainder were anesthetized with nitrous-oxide-oxygen, nitrous-oxide-ether, caudal or intravenous anesthesia. Thirty patients of the 6,553 operated upon in this series developed atelectasis. This is an incidence of .45 per cent.

The patients developing atelectasis were all males and their ages ranged from eighteen to forty-four years; 77 per cent of the patients were between eighteen and thirty-two years of age. The results of this study are in accord with the findings of Rink<sup>30</sup> and Brunn and Brill<sup>4</sup> that there is no particular seasonal in-

cidence in the occurrence of this complication. Even though the personnel on this Post experienced two severe respiratory epidemics each lasting about four months, no increase in atelectasis during those intervals was noted.

### ETIOLOGY

Gairdner,<sup>9</sup> in 1850, differentiated atelectasis from pneumonic consolidation and states that it was due to bronchial obstruction. Pasteur,<sup>28</sup> in 1890, described atelectasis following diphtheria and subsequently in 1914,<sup>29</sup> discussed fourteen cases occurring in a series of 2,000 abdominal operations which he, on the basis of his earlier observations, believed were secondary to paralysis of the diaphragm. Since then, much experimental work has been done in an effort to establish the etiology of postoperative atelectasis. Lee and Tucker,<sup>21</sup> in 1925, studied a patient bronchoscopically and noted that the bronchi of the atelectatic lung were completely occluded with thick, tenacious secretion. Lee et al.,<sup>22</sup> in 1928, produced atelectasis in dogs by obstructing a bronchus with bronchial secretions removed from a patient with massive atelectasis. Coryllos and Birnbaum,<sup>7</sup> the same year, produced atelectasis in dogs by plugging a bronchus with a rubber balloon. These findings were substantiated by Adams and

\* AAF Regional Hospital, Keesler Field, Mississippi.



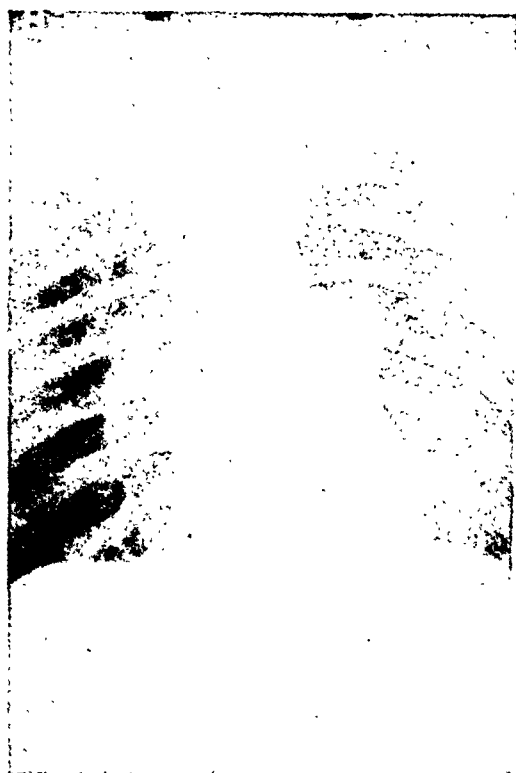


FIG. 1. Lobular atelectasis.



FIG. 2. Lobar atelectasis.

Escudero<sup>1</sup> who occluded bronchi in dogs by the use of 35 per cent silver nitrate or thermal cautery. In a series of laparotomies, postoperative measurements by Muller, Overholt and Pendergras<sup>26</sup> showed a marked reduction in the vital capacity. They believed that this, plus impaired cough with retained bronchial and salivary secretions served to explain many of the cases of postoperative atelectasis. Although other factors have been postulated and might conceivably be a factor, namely, the vagal reflex theory<sup>5,36,2</sup> bronchospasm and edema<sup>39</sup> and reflex bronchoconstriction and bronchosecretion,<sup>8</sup> the mass of clinical evidence supports the theory of the mechanical obstruction of a bronchus or of one or more of its branches. This may be caused by retained secretions which have collected in the tracheobronchial tree during anesthesia, by mucopurulent material which was present preoperatively or by mucus, blood or vomitus which has been aspirated into the trachea either during or immediately following anesthesia. This results in a gradual

absorption of air from within the obstructed alveoli by the blood stream with complete airlessness of the involved lung tissue (lobular, lobar or massive, depending on the site of the obstruction). When the obstruction is relieved the atelectatic lung tissue is promptly re-aerated.

*Preoperative Medication.* Thirteen of the patients of this series who developed atelectasis had received morphine sulfate, Gm. 0.016, prior to operation, fourteen, morphine, Gm. 0.016 and scopolamine, Gm. 0.0003, one, morphine, Gm. 0.016 and atropine, Gm. 0.0006, one, morphine, Gm. .016 hypodermically plus morphine, Gm. 0.016, intravenously and one, intravenous sodium pentothal. Mousel<sup>25</sup> has voiced objections to the preoperative use of atropine and scopolamine, for although these drugs reduce the amount of salivary and bronchial secretions, it is believed that they are responsible for the drying of the secretions which are present until they become so tenacious that the ciliated epithelium of the bronchial tree is unable to propel the secretions up the

trachea. While these objections are valid in the immediate postoperative course, it is believed that in view of the fact that approximately one-half of the patients in this series who developed atelectasis had received scopolamine and the remainder had not, the addition of this drug in itself played no significant part in the production of this complication. The value of the use of these vagatonic drugs in the prevention of postoperative pulmonary complications and vomiting is stressed by Goodman and Gilman.<sup>10</sup> The decrease in vagatonus and the respiratory stimulating action of atropine and scopolamine are physiological effects to be desired during the operation and in the period immediately following the procedure. Waters et al.<sup>33</sup> have shown that scopolamine with morphine in the ratio of 1 to 25 will increase the respiratory rate over that of patients receiving morphine only.

Mousel<sup>25</sup> advises against the routine practice of giving sedatives the night before and the morning of operation, as it may put the patient in a somewhat stuporous state so that the patient has no urge to expectorate the secretions which have accumulated during the night. While this might be true in the case of some of the sedatives, it has been found in this series that the use of a relatively mild, rapidly acting and rapidly excreted barbiturate, such as nembutal, Gm. 0.1 or seconal, Gm. 0.1, the night prior to operation has sufficed to give the patient a comfortable night's rest with no soporific after-effects the following morning and no interference with the cough reflex. In view of the fact that heavy smokers usually have tenacious mucus in their air passages, Mousel<sup>25</sup> discourages their smoking prior to operation.

*Postoperative Medication.* The use and abuse of morphine postoperatively has been justifiably emphasized by Kerr,<sup>19</sup> Schmidt, Mousel and Harrington<sup>35</sup> and Marshall.<sup>23</sup> The cough depressant effect of morphine, especially when repeatedly

given in the immediate postoperative period, is a definite factor in the retention of secretions and the production of atelectasis. However, narcotics, when judiciously used, have definite value in the postoperative care of any patient. One who is in considerable pain will certainly suppress any cough or will limit any motion which might tend to aggravate that discomfort. Hence, morphine in Gm. 0.008 or 0.016 doses, or preferably, a less potent cough depressing drug, such as codeine, Gm. 0.032, may be given to alleviate the patient's discomfort. However, it is believed that the practice of leaving a routine postoperative order for morphine Gm. 0.016 every four hours with no further instructions to the nurse or intern to withhold the drug as much as possible, should be discouraged. It has been observed in this series that many of the patients, when lying quietly in bed are quite comfortable but when they try to move around or when they are instructed to try to cough, they experience considerable pain. The application of manual pressure over the operative site on those occasions will eliminate much of the pain and obviate the need for another hypodermic.

*Operation and Anesthesia.* In a review of the types of operations done in this series of patients who developed atelectasis it was noted that there were nine appendectomies, eighteen herniorrhaphies, two simple closures for ruptured duodenal ulcers and one nephrectomy. The anesthesia used on all patients but two was spinal. The two exceptions were one appendectomy in which intravenous sodium pentothal was used and the other, a herniorrhaphy in which the spinal anesthesia was supplemented by sodium pentothal. It has been stated by Rink<sup>30</sup> and King<sup>20</sup> that the type of anesthesia, *per se*, has no influence on the development of atelectasis. Schmidt, Mousel and Harrington<sup>35</sup> noted that when spinal anesthesia is given for upper abdominal or renal surgery, there may be a motor

paralysis up to the fourth thoracic segment. The resulting paralysis of the lower intercostal muscles causes reduced pulmonary ventilation which favors stagnation of the bronchial secretions.

In this series, all of the patients in which massive collapse developed were on the operating table for at least sixty minutes, whereas the duration of the operation of the patients that developed a lobular type of atelectasis averaged forty-seven minutes. So, it would seem that the longer the operation, the greater the chance for secretions to accumulate in the bronchial tree. Rovenstine and Taylor<sup>31</sup> in a study of 7,874 operations found that operations lasting one hour or less were followed by less than the average number of lung complications. When the operation lasted from one to one and a half hours, the incidence increased from 50 to 100 per cent. Those operations lasting two hours were followed by three times as many lung complications as those lasting one hour.

#### SIGNS AND SYMPTOMS

Nine of the patients in this series developed clinical and roentgen evidence of atelectasis on the first postoperative day, thirteen on the second day, six on the third day and one each, on the fourth and fifth day, respectively. Thus, 93 per cent of the patients presented demonstrable evidence of atelectasis within the first three days of their operation.

The most frequent symptom noted was cough. This was the initial complaint in twenty-five patients (83 per cent) and was in most instances dry at the onset. In eighteen of the patients (60 per cent) this was the only complaint. Shortness of breath was noted in six instances (20 per cent), chest pain in five (17 per cent), blood streaked sputum in two (7 per cent), cyanosis in one (3 per cent) and chill in one (3 per cent). All of the patients except one, (97 per cent) showed a rise in temperature ranging from 101°F. to 104°F. degrees. The pulse rate was over

100 per cent in twenty-eight of the thirty patients (93 per cent). The respiratory rate in all but one patient was over twenty per minute, the majority of the patients having a rate between twenty-two and thirty. The textbook description of the sudden onset of chest pain, dyspnea and cyanosis has been conspicuous by its absence.

Physical examination of the chest was negative in one patient and revealed only diminished breath sounds in twelve patients. In the remaining seventeen patients, the following signs were noted in varying degree depending on the extent and type of atelectasis: diminished chest expansion, diminished fremitus, diminished breath sounds and crepitant or subcrepitant râles.

#### LABORATORY PROCEDURES

In the study, Churchill and Holmes's<sup>6</sup> classification in differentiating the types of atelectasis as noted on the x-ray film, namely, lobular (segments of one or more lobes), lobar (an entire lobe) and massive (all lobes of one lung) has been adopted. The site of the obstruction determines the location and extent of the collapse. Twenty-one of the cases (70 per cent) were of the lobular type, three (10 per cent) were lobar, and six (20 per cent) were massive. In many of the patients who showed a lobar or massive collapse, the x-ray revealed a slight to moderate haziness over the involved lung field and not the dense opacity so frequently referred to in typical cases of massive collapse. In the latter instances described in the literature as typical massive collapse, the obstruction had existed for some hours and a complete absorption of the retained air had occurred. In those patients in this series who showed a less dense shadow on the x-ray film, the obstruction had existed for a relatively short period of time and the air retained in the obstructed alveoli had not had sufficient time to become absorbed by the blood stream. It was soon obvious that the mediastinal shift to the involved

side and the elevation of the diaphragm were less marked in the cases of lobular atelectasis than it was when the condition was of the lobar or massive type. This has also been noted by Schindler and Gnagi.<sup>34</sup> In five of the patients having lobular atelectasis, no apparent elevation of the diaphragm and no mediastinal shift were noted. From a purely roentgenological standpoint, these lesions could not be differentiated from the roentgenological findings usually associated with bronchopneumonia. However, the rapid and complete disappearance of the densities associated with the rapid clinical response after institution of therapeutic measures proved them to be areas of atelectasis.

All of the patients had a white blood cell and differential count at the time of the development of this complication. A leukocyte count above 12,000 was noted in 75 per cent, the highest white blood cell count being 19,450. A polynucleosis above 70 per cent was found in 92 per cent of the patients. Sputum studies were obtained in only one-half of the number of patients. Two of them revealed the presence of pneumococci, one a type 19 and the other a type 15.

#### DIAGNOSIS

Suspicion of its existence is the most important single factor in the early diagnosis of pulmonary atelectasis. To await the development of a definite clinical picture is to wait too long. The earlier a diagnosis is made, the simpler will be the therapy needed for a cure. In addition, the possibility of a secondary pneumonia developing will be greatly minimized. As it was noted in this series of patients that the most frequent findings were a temperature of 101°F. or more (96 per cent), a pulse rate of 100 or more (93 per cent) and a respiratory rate of 22 or more (96 per cent), a study was made of 100 unselected charts of patients having had uncomplicated herniorrhaphies or ap-



FIG. 3. Massive atelectasis.

pendectomies. Five patients in the entire group, all having undergone herniorrhaphy, had a temperature over 101°F. Four of them had a pulse rate of 100 or more and four had a respiratory rate over 20 per minute. A careful perusal of these five charts further revealed that on the first postoperative day in four patients and on the second postoperative day in the fifth patient at the time of their temperature elevation, all complained of a cough and had expectorated some phlegm. Subsequently the temperature, pulse rate and respirations returned to normal on the second day in one patient and on the third day in the others. Chest x-rays were taken in three of the patients and were normal. It is believed that such instances might justifiably be classified as patients with "subclinical atelectasis," that is, they had accumulated sufficient secretions to obstruct some portion of their bronchial tree and to cause a febrile response. By the use of one of the hyper-ventilation regimens routinely used and conceivably in other cases by the patients'

own efforts and cough reflex, the obstructing secretions were expectorated before sufficient air had been absorbed to cast a shadow on the x-ray film. In six other patients, the temperature had reached 101°F. but the pulse rate and respirations were below 88 and 18, respectively. In ten other patients, the temperature was between 100°F. and 101°F. and the remaining seventy-nine patients never had a febrile response of over 100°F. Therefore, it is believed that a patient, who within the first three or four postoperative days, develops a temperature of 101°F. or more, a pulse rate of 100 or more and a respiratory rate of over 20, should be suspected of having either a subclinical atelectasis (without x-ray findings) or a clinical atelectasis (confirmed by x-ray examination) if no other cause is evident. In either case, every attempt should be made to facilitate cough and expectoration of the retained secretions. This must be done early if the best results are to be obtained.

#### TREATMENT

*Prophylaxis.* The most important phase in the therapy of postoperative atelectasis is its prevention. During the period covered by this study, all of the accepted forms of postoperative routines, such as, frequent turning of the patient, deep breathing exercises, blow bottles, paper bag rebreathing exercises and carbon dioxide (10 per cent) and oxygen (90 per cent) inhalations have been tried at different times. Holinger et al.<sup>13</sup> have shown that carbon dioxide inhalations tend to liquefy bronchial secretions and hence inhalations of this gas will facilitate their expectoration. In this study it has been found that all are useful and about equally effective. Any procedure which has for its purpose the hyperventilation of a patient and will stimulate the cough reflex should be incorporated in every postoperative routine. Nurses and ward personnel must be carefully trained in the routines to be used so that maximum

results, namely, cough and expectoration, will be obtained. Equally as important as the hyperventilation regimen is the avoidance of elective surgery on patients with respiratory infections. Ideally, a patient who has had an upper respiratory infection should have an interval of ten to fourteen days free of symptoms before an elective operation is done. Pre-existing upper respiratory infections are most important antecedent factors in the increased production of bronchial secretions. Any patient with a history suggestive of a chronic bronchitis or bronchiectasis should be deferred until a sufficient interval has passed, during which time treatment, including postural drainage, has been utilized to its fullest extent. If necessary, bronchoscopic drainage should be included both preoperatively and immediately postoperatively. The use of nebulized penicillin has been advocated recently<sup>3,18,27</sup> and appears to show much promise in the preoperative preparation of patients with chronic bronchitis and bronchiectasis. In many of the patients treated by this method, a reduction was noted in the amount of expectoration which becomes thinner and less purulent. Any patient with asthma should be deferred until all chest signs have cleared and the cough has subsided. In one patient in which this could not be done, a massive atelectasis of the left lung developed on the second postoperative day and had to be treated by bronchoscopic aspiration. The avoidance of constricting bandages about the thorax and the efficacy of using the Trendelenburg position during and immediately after operation have received sufficient emphasis in previous publications.

*Active Therapy.* Active therapy is necessarily directed to the removal of the obstructing secretions. It is believed that once the diagnosis of atelectasis is made, that an acute emergency exists and treatment should be instituted immediately. The success of any therapeutic procedure in atelectasis depends on the successful

removal of the obstructing agent with complete reaeration of the affected lung tissue. The return of the temperature and pulse and respiratory rates to normal is a fairly good index of the effectiveness of the treatment employed. In twenty-two patients (73 per cent) the temperature dropped to normal within twenty-four hours, in seven patients (23 per cent) within twenty-four to forty-eight hours and in one patient (3 per cent) within forty-eight to seventy-two hours. This ran parallel with the return to normal of the chest findings both on physical examination and repeated x-ray studies.

Efforts to stimulate cough by deep breathing exercises, frequent turning, re-breathing into a paper bag, and by turning the patient on the unaffected side and thumping on the chest over the affected side will frequently be sufficient.<sup>17,33</sup> These simpler procedures were effective in fourteen patients. (47 per cent) Carbon dioxide (10 per cent) with oxygen (90 per cent) inhalations were successfully used in nine patients (30 per cent) and the addition of ether supplementing the carbon dioxide-oxygen inhalations accounted for three other cures (10 per cent). Bronchoscopic suction was used with dramatic effect on the remaining four patients (13 per cent) who had not responded to the other measures. Three of these patients had lobar atelectasis and one patient massive atelectasis.

Should the simpler therapeutic measures be ineffective, the anesthesia machine is brought to the patient's bedside and carbon dioxide-oxygen (10-90) inhalations are started by the anesthetist. When a definite carbon dioxide effect is produced as shown by increase in amplitude and rate of respiration, the patient will frequently develop a forceful and expulsive cough. Several inhalations may be necessary to expel the plug. In some patients, however, this has not been accomplished and in those instances, the anesthetist (P. S. M.) has modified this procedure by adding the so-called "ether technic"

which he has developed with excellent results. After the carbon dioxide effect has been produced, the ether vaporizer is suddenly and completely cut in. Because of the powerful stimulus to respiration by the carbon dioxide, the patient will inspire the highly concentrated ether mixture even though it is markedly irritating. About three inspirations will produce an irrespirable level of ether concentration and a forceful cough reflex is initiated. Manual pressure over the operative site must be applied firmly by an attendant during this procedure. It may be necessary to repeat this procedure in a few minutes. If a beneficial effect is produced, as evidenced by the expectoration of a large plug of mucus or copious amounts of secretion and the involved lung shows an increase in aeration, this may suffice. If but little improvement is noted, the procedure is repeated at hourly intervals for three hours. This will almost completely cure those patients who are going to respond to this method of treatment. A physical examination of the chest and a follow-up x-ray should be made at this time. A marked improvement in the findings in the presence of a productive cough is evidence of satisfactory progress. It is believed that a trial with this technic is justified in all types of atelectasis and it has proved to be of definite value. A patient with massive collapse (Fig. 3) received this therapy after the "stir-up" regimen was attempted without success. His response was excellent and large amounts of sputum were expectorated. Three hours after this initial treatment a chest x-ray showed only several residual lobular atelectatic densities. The patient was encouraged to cough and was turned frequently. No further therapy was administered. An x-ray of the chest taken the following day was normal.

Should none of these procedures be successful, bronchoscopy must be instituted. Reports in the literature,<sup>11,12,14,15,16,21,25</sup> regarding the efficacy of this mode of therapy are definite and conclusive. The

results of this study are in accord with the observations of others<sup>24,32,33,35</sup> that there is no need for immediate bronchoscopy in every patient that develops an atelectasis. However, it is believed that if the simpler methods of therapy are not successful, not more than three or four hours should be permitted to elapse before bronchoscopic drainage is instituted. This is well illustrated by two patients who at the time the diagnosis was made had a lobular type of atelectasis but the condition failed to respond to the usual conservative therapeutic measures. X-ray films of the chest of these individuals were repeated prior to bronchoscopy which was performed eighteen and twenty-four hours later, respectively. These films showed that the atelectatic process had progressed from a lobular to a lobar type.

The benefit to be derived from the routine use of chemotherapy in cases of postoperative atelectasis is conceivably debatable. It has been observed in this series that as soon as the obstructing secretions are removed, there is prompt clinical and roentgenological improvement. However, in those patients who are not promptly relieved of their obstruction, the likelihood that pneumonia will develop is great. Schmidt, Mousel and Harrington<sup>35</sup> believe that any atelectasis which exists for seventy-two hours or longer would have a slow recovery and by that time there would be clinical evidence of secondary pneumonia. Schindler and Gnagi<sup>34</sup> in their study occasionally found pneumococci in the sputum which were of the lower types and of potential pathogenicity. Marshall<sup>24</sup> and Thompson<sup>37</sup> favor the use of chemotherapy with one of the sulfonamides as a prophylactic measure against the development of a pneumonia. Twenty-one patients of this series received sulfadiazine when the diagnosis of atelectasis was made. None of the patients, neither those who received the drug nor those who did not receive it, developed a complicating pneumonia. It is believed that ordinarily there is no contraindication

to the use of chemotherapy prophylactically but it should always be borne in mind that removal of the obstructing secretions is the sole means of obtaining a rapid and complete cure without serious or permanent sequelae.

The use of the tracheal catheter has been advocated by Marshall<sup>24</sup> and Thompson.<sup>37</sup> Where the simpler measures fail and no bronchoscopist is available, this method is certainly indicated. However, in inexperienced hands, it is conceivable that the vocal cords and larynx may be injured and laryngeal spasm initiated. The use of artificial pneumothorax has also been tried with some success by Schindler and Gnagi<sup>34</sup> and Jacobson, Gendelman and Goldman.<sup>17</sup> Following the obstruction of a bronchus, the retained air is absorbed with a resulting increase in the intrapleural negative pressure. The introduction of air into that pleural space causes a diminution in the degree of negative pressure which, theoretically, should favor expulsion of the plug. The last two procedures have not been employed in this series.

#### CONCLUSIONS

1. Postoperative pulmonary atelectasis is caused by retained secretions which have obstructed a bronchus or its radicles.
2. Pulmonary atelectasis may either be lobular, lobar or massive depending on the site of the obstruction.
3. Suspicion of its existence is the most important single factor in the early diagnosis of pulmonary atelectasis.
4. A postoperative rise in temperature above 101°F. associated with a pulse rate of 100 or more and a respiratory rate above 20 within the first three or four days after operation should make one suspect the onset of atelectasis. Once the diagnosis of atelectasis is made, an acute emergency exists and treatment should be immediately instituted.
5. The simple conservative methods of therapy should be tried first.
6. Eighty-six per cent of the patients

with postoperative atelectasis were cured without the use of bronchoscopic drainage.

7. The use of the carbon dioxide-ether technic, as described, has been a valuable procedure in the treatment of the patients in this series who did not respond to the simpler measures.

8. If other forms of therapy are completely ineffective after three or four hours of persistent use, bronchoscopic drainage should be instituted.

9. Therapy must be directed towards the removal of the obstruction and must be instituted promptly to be effective.

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# CAUDAL TRANS-SACRAL ANESTHESIA IN RECTAL SURGERY

ITS ROUTINE USE IN MORE THAN 2,000 CASES

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THE revival of the question of anesthesia for rectal surgery is the logical result of the new interest in proctologic problems which began ten years ago. At that time the significance of rectal surgery as a speciality was enhanced by the clarification of the surgical anatomy of the anorectum. When it was found that the sphincteric musculature was formed as a web (not as a series of rings as had always been supposed), many useful inferences arose for the surgeon. For the first time he was able to recognize guiding landmarks which showed him where to make his incisions, how deep to make them and where not to make them. For the first time he was able to solve that century-old problem: how to create safe and adequate drainage in a vulnerable anatomic structure where safe and adequate drainage is imperative.<sup>1</sup> Equal in importance to the advantages of these discoveries was the awakening of a critical attitude that led the surgeon to investigate many problems affecting the rectal surgical patient.

Among these proctological problems the administration of caudal trans-sacral anesthesia stands prominent. This does not mean that anything particularly new has been added to the question of spinal versus sacral anesthesia in rectal surgery; it means that the surgeon has been encouraged to undertake the sacral method in spite of its supposed difficulties because its manifold advantages are becoming more apparent.

A few years before the clarification of the surgical anatomy, with its ensuing chain of practical modifications of surgical methods, the question of anesthesia was apparently settled. Although everyone

knew that many sequelae were inherent in the spinal method, it was condoned by expediency. On the other hand, while everyone knew that the sacral method not only avoided these sequelae, but provided many advantages for the rectal surgical patient, most practitioners were restrained by the apparent difficulties of the method. The situation was summed up accurately and fairly in the statement: "The widespread use of spinal anesthesia probably is due to the fact that it is easier to administer than sacral block anesthesia. In fact, to many surgeons who administer their own anesthetic agents, blocking of the sacral nerves is an insuperable problem. There are certain undesirable features about spinal anesthesia, chief of which is the headache which all too frequently follows and which often disturbs the patient more than the operation."<sup>2</sup>

Today, however, the rectal surgeon no longer concedes that this valuable method is beset by insuperable obstacles. He realizes that all the objections to the sacral method are based upon the technical difficulties which are said to be inherent in it. He realizes that the caudal-sacral method not only avoids the inimical sequelae of the spinal method, but that it is especially suitable for rectal surgery. It facilitates postoperative care, it creates a "saddle anesthesia" which is particularly appropriate to proctologic surgery; it is affected by none of the contraindications which are directed to the spinal method.

In addition, this new attitude is influenced by two other factors: First, the choice of the patient is becoming more cogent; with increasing frequency, he

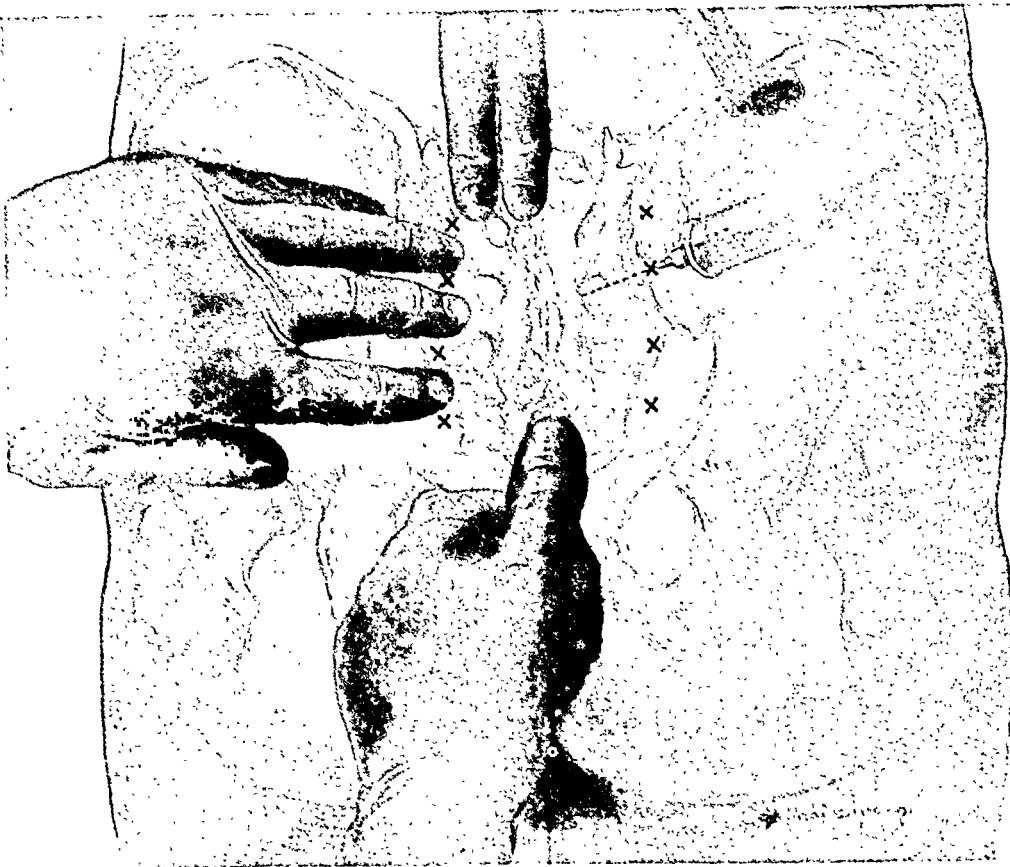


FIG. 1. Schematic drawing to show how to locate the sacral foramina in the administration of caudal trans-sacral anesthesia. The sacral hiatus is detected by pressing thumb between sacral cornua. Sacral foramina lie one finger-breadth lateral to the midline and are separated by the distance of one finger-breadth. Points of needle insertions lie one finger-breadth lateral to the sacral foramina because skin can be moved toward the midline not away from it (X).

flatly refuses spinal anesthesia. Second, an ever increasing number of men use the sacral method routinely, and thereby obtain all the advantages of a safe and effective anesthesia and avoid all the untoward effects of the spinal method. For example, observe Dr. Buie's statement which was made ten years ago: "At the Mayo Clinic we have employed sacral block anesthesia in more than 15,000 cases, we are still favorably impressed by it and prefer it to all other methods. It is the ideal anesthetic for proctologic surgery and when combined with proper preoperative sedation, it provides those virtues which characterize anesthesia in any field of surgery, namely, complete freedom from fear, complete mental relaxation, complete muscular relaxation, adequate exposure of the operative field and complete anesthesia."

Because our own experience is in full

accord with that of others who have employed it in a far greater series, we mention the following factors which we have found to be useful:

First, the order of the learning process is important. We have always been told that the seat of the learning process lies in the neuromuscular apparatus, that skill is increased by lessening the resistance in the neural synapses by frequent, conscious repetition of the action in question. This procedure, we are informed, develops the sense of kinesthesia—the "muscle sense." This is to say that actual practice is the key to the learning process.

Unfortunately, the customary method of learning caudal trans-sacral anesthesia is just the reverse. The student has usually been primarily concerned with the study of landmarks and descriptions, watching demonstrations, and then trying to transfer that vicarious experience to his own neuro-

muscular mechanism. It does not work. Because the "muscle sense" must be trained first, the study of descriptive literature and the observation of expert demonstration should be deferred until actual manipulation has been undertaken.

The first thing to do, therefore, is to obtain sacra and start handling them. Go to your nearest medical school and procure a large number of sacra and begin to get the feel of them. The "feel" will acquaint the student with many valuable factors which constitute the key to learning how to administer the anesthesia. He will note relationships; he will note the slant of the foramina, their size and shape, the distance between them; above all, he will note the large size of the foramina and will begin to develop a confidence and he will see that those foramina are impossible to miss.

Just as important a benefit to be derived from this actual handling of sacra is the recognition of anomalies. Whereas anomalies are occasionally encountered in other parts of the body, here they are the rule, not the exception. The student will see that no two sacra are alike. Therefore, he will realize that didactic attempts at description will not help. For example, he will note that the percentage of bifid sacra is very high. This will explain why the caudal injection of solution may run out as fast as it is injected and will warn him that the trans-sacral injection should always accompany the caudal.

This actual handling and study of deformed, twisted, gnarled, and distorted sacra will afford the student the real essence of learning. While he will be convinced that the so-called normal sacrum is a vagary and while he is likely to be disappointed to realize that arbitrary landmarks cannot be depended upon, he will be compensated by a number of other things which he will learn by the actual handling of sacra. He will develop a sense of touch which will give him confidence in the method.

This is the time for him to undertake the second step, which is the actual

practice on the cadaver. With twelve 2½ inch, No. 19 gauge, needles, he will visit the morgue, autopsy room, or anatomic laboratory and after surmounting any and all obstacles to access to a cadaver, will start experimenting with the needle insertions. This practice on various cadavers will afford much useful information concerning the administration of the method. He will note that the panniculus adiposus, toughness of the skin and bony landmarks are things to be dealt with. Here again, a certain amount of practice will reveal many ideas that will build up confidence that is derived from the mere studying of sacra. Here again, this confidence will be the clue to undertake the third step of the learning process which is actual practice on the patient.

This is the easiest stage of all. The preliminary practice of the first two stages of the learning process will enable the operator to perform the procedure with facility; it will convince him that the foramina are large and easily accessible and his confidence in the method will be increased.

Here, a few practical suggestions may aid in locating the foramina. If the patient is a "large-boned person," the foramina are separated by distances of "large finger-breadths"; if the patient is a "small-boned person," they are separated by "small finger-breadths." How these "finger-breadths" can be used may be inferred by inspection of the accompanying schematic drawings. The operator notes that the foramina lie lateral to the mid-sacral line about the distance of one "finger-breadth." (Fig. 1.) He will note, however, that the point for insertion of the needle should be two "finger-breadths" (Fig. 1x) because the skin can be moved toward the midline only, not away from it. He will note that the foramina are approximately one "finger-breadth" apart. Finally he will note that the sacral triangle is readily detected by "sinking a thumb into it."

These few delineative remarks are all

that are necessary to afford a practical working plan for the operator. Anything more would clutter up his concept. He will have been convinced by his previous experience with handling sacra, and examining a large number of them, that the wide prevalence of anomalies defeats any attempt at exact, definitive, localization of landmarks. This previous experience, together with his work on the cadaver, will have afforded him a much more useful aid; it will have provided him with that sense of touch which is the *sine qua non* for the administration of sacral anesthesia.

Now a few words of admonition derived from our moderate experience: (1) Inspect the armamentarium before it is used. Examine needles for fragility. Examine stillettes and see that they fit. (2) In making trans-sacral injections incline the needle slightly toward the midline rather than perpendicularly because the canals are wider in their transverse diameter. (3) Insert the needle laterally to the estimated opening, because the skin may be moved toward the midline, not away from it. (4) After insertion of the needle

aspirate for blood and, if it appears, replace the needle and inject slowly. (5) After inserting the sacral needle aspirate carefully because, in one case out of forty, we have found that spinal fluid appears at the sacral foramen when the spinal needle is used. For that reason we have employed the  $2\frac{1}{2}$  inch needle routinely for injection of the caudal canal. (6) In withdrawing the caudal needle, pull in the same axis as the caudal canal so as to avoid breakage.

#### COMMENT

Our experience with the caudal-sacral method of anesthesia during the past fifteen years during which time we have employed it in more than 2,000 cases has been uniformly satisfactory. True, there is reasonable effort required to learn the method, but we believe that the burden should be shouldered by the doctor, not by the patient.

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# INJURIES TO THE SEMILUNAR CARTILAGES OF THE KNEE JOINT\*

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THE semilunar cartilages of the knee joint are so situated as to be peculiarly vulnerable to injury. Such injuries all too often remain untreated and result in continued pain and disability. This may be due to failure to establish an accurate diagnosis, or to fear of operation on the part of the patient. The diagnosis is usually not difficult, and the results of treatment are extremely gratifying. It is our purpose to review briefly this subject and to prevent our experiences with 126 cases admitted to the surgical service of this hospital.

## HISTORY

Proper credit for the earliest description of semilunar cartilage injuries is poorly established. The nineteenth century literature contains numerous references to the condition which is designated as "Hey's Internal Derangement of the Knee Joint."<sup>1,2,3</sup> In 1816, Dorsey<sup>4</sup> in his surgical text publishes a portion of Hey's description of the condition as follows: "This joint is not infrequently affected with an internal derangement of its component parts, and that sometimes in consequence of trifling accidents. The disease is, indeed, now and then removed, as suddenly as it is produced, by the natural motions of the joint without surgical assistance; but may remain for weeks or months, and will then become a serious misfortune, as it causes a considerable degree of lameness . . ."

In 1882, Knott<sup>5</sup> also credits Hey as follows: "In the volume of 'Practical Observations in Surgery,' published by Mr. Hey of Leeds is included a paper

'On Internal Derangement of the Knee Joint' which contains the original description of the very peculiar lesion to which the name of this distinguished surgeon has been attached." However, from a footnote at the termination of Knott's paper the following is of some historic interest: "In the discussion on this paper it was remarked by Professor Bennett that a case of dislocation of one of the semilunar cartilages of the knee joint was recorded by Mr. Bromfield some years previous to the appearance of Hey's well known work. I have since found, on comparing dates, that the cases (two in number) of dislocation of the semilunar cartilages recorded by Bassius (*Obs. Anatomico-Chir.-Med.*, Decad. 11., *Obs.* v) were published before those of either of the latter observers."

On the other hand Castiglioni<sup>6</sup> gives full credit to Annandale, stating that loose cartilages in the knee joint were first recognized by him in 1879 and removed by him in 1883. We cannot be certain whether this statement refers to displaced semilunar cartilages or to free cartilagenous bodies, the so-called joint mice. However, we believe that loose bodies were well known before and during this period<sup>7-11</sup> and that the reference is to meniscus injuries. A search of the literature reveals an interesting report by Annandale<sup>12</sup> in 1885 of an operation for displaced semilunar cartilage. The medial meniscus was found detached at the anterior pole and displaced backward to the center of the joint. Correction consisted in suturing the cartilage back in its normal position. The possibility of removal of the cartilage was not mentioned in this publication.

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Recovery was uneventful and all symptoms were alleviated.

During the past five years a diagnosis of semilunar cartilage derangement has been registered in 126 cases admitted to the surgical service. Additional cases were seen in the out-patient department but are not included in this study. One hundred twelve were treated by surgical exploration of the knee joint either on the first or a subsequent admission into the hospital. Of the fourteen patients not receiving operative treatment, five were handled satisfactorily by conservative measures and became asymptomatic. Five were discharged at their own request without treatment. The remaining four were Coast Guardsmen who refused operation and were discharged from military service.

The work of the majority of these men as merchant seamen and Coast Guardsmen precludes late follow-up studies in any satisfactory percentage of cases. Practically all of them were followed for a few months as out-patients until they returned to duty. If unable to return to duty, or if symptoms persisted, they were almost invariably returned to the hospital for treatment or further disposition. The results are discussed more fully under prognosis.

#### ETIOLOGY

The classical story associated with a torn cartilage is a sudden twisting strain sustained on a slightly abducted and flexed knee. In extension the cartilage is forced into a protected position; it is only in flexion that it is subject to trauma. A review of the histories in our cases shows that less than one-third of the patients remembered any element of twisting at the time of the injury, but the knee was flexed in all cases. In several cases a classical picture of torn cartilage was present with no history of injury whatever. With the exception of the industrial cases and those in military service, football probably ranks first as the cause of torn cartilages. Many of our military patients

gave a history of an old injury sustained while playing football in civilian life. Few symptoms were present in sedentary civilian activities. More active military life called attention to the old lesion and frequently brought the patient to the hospital. Poor muscular development definitely predisposes to cartilage injury. The injury is much more common in the male. While female patients account for 11.3 per cent of our hospital admissions, only 6 per cent of our cartilage cases are women. The low relative incidence in women is attributable to their less strenuous activities.

#### SYMPTOMATOLOGY

The clinical picture is variable, but usually there is acute pain and swelling of the knee immediately following an injury. The pain may be referred to the surface of the knee opposite the point of the tear or poorly localized within the joint. Inability to extend the knee completely is a characteristic feature, but locking was present in only one-third of our cases. Locking may be present at the onset or may occur for the first time much later. Henderson points out that the initial locking may occur while the patient is in bed.<sup>13</sup> After the acute symptoms of pain and swelling subside, various degrees of chronic disability develop. Pain results from any set of conditions which produces a strain on the partially flexed knee, such as walking up or down hills, stairs, ladders or over rough ground.

Locking or a "giving way" of the joint may occur without warning in the course of ordinary activities. These attacks are the result of displacement of the torn portion of the cartilage into a position where it acts as a mechanical block. Such attacks are usually followed by a period of swelling and discomfort. Between attacks the patient may be relatively free of symptoms.

Quadriceps atrophy, which is almost always present in the chronic cases, increases further the instability of the joint

and contributes to the common complaint of the limbs "giving way." Occasionally, a patient may actually be thrown to the ground by a simple maneuver, such as stepping from a curb.

#### PHYSICAL FINDINGS

In the acute phase, there is swelling with obliteration of the normal concavities about the knee. This swelling is due to the collection of fluid and blood in the synovial sac. In the chronic case, there is little or no knee joint swelling, but atrophy of the quadriceps muscle is common. By palpating the superior margin of the tibia on the affected side, localized tenderness can be demonstrated over the cartilage. The degree of tenderness depends upon whether the injury is a recent or an old one. In some cases the knee is locked when first seen. When this is present the knee cannot be fully extended, and there is only a small range of motion present. It is rarely locked in the sense that no motion is possible. A locked knee usually signifies a severe tear in the cartilage. A useful diagnostic point in the examination of the chronic knee is brought out by having the patient extend the knee forcibly and suddenly. If he is unable to do this or if pain is elicited, internal derangement of the knee, most probably cartilage disorders, are indicated.

Where a rupture is present in the extreme posterior quadrant of the cartilage, full extension may be possible without discomfort. If the knee is sharply flexed and rotated, a distinct "snap" may be elicited with the production of deep seated pain in the joint, a sign diagnostic of posterior cartilage rupture.

#### X-RAY TREATMENT

An x-ray of the knee is taken routinely for the purpose of ruling out arthritis, fracture, or some other pathological condition. Key and Conwell<sup>14</sup> advocate x-rays following the introduction of air into the synovial cavity in doubtful cases. In some

cases they have been able to outline the actual tear in the cartilage. We have been able to obtain but little useful information for this procedure. Some radiologists state that narrowing of the joint space on the affected side is a valuable sign in the diagnosis of cartilage injury. Although we have seen this sign in a few cases, later proved to have cartilage tears at operation, we have not been impressed with its consistency. We believe that x-ray studies have an important but negative rôle in the diagnosis of cartilage injuries.

#### DIAGNOSIS

The presence of cartilage injury is almost invariably suggested by the history. When it is suspected, it can be satisfactorily demonstrated on physical examination in a very high percentage of cases. The arthroscope has been advocated by Mayer and Burman<sup>15</sup> as an aid in diagnosis. We have not used this instrument, but its field of usefulness appears to be limited by the anatomical arrangement of the joint. Furthermore we believe that examination with such an instrument unnecessary.

There are many other conditions which can simulate meniscus injury and should always be borne in mind in the differential diagnosis: (1) Chronic arthritis can produce many of the signs of cartilage injury. The hypertrophic type can be seen in the x-ray film. But rheumatoid arthritis which involves chiefly the synovia and soft structures of the joint may present a more difficult problem. We have seen at least one case of tuberculous arthritis of the knee joint explored with a preoperative diagnosis of torn semilunar cartilage. (2) Osteochondritis dissecans is a much more common condition than is generally realized. Caldwell reports finding degenerative changes of the articular cartilage in 67.6 per cent of medial femoral condyles viewed at operation.<sup>16</sup> Osteochondritis dissecans is characterized by erosion of the articular cartilages of the joint with freeing of loose bodies into the synovial cavity. There "joint mice" can become lodged between

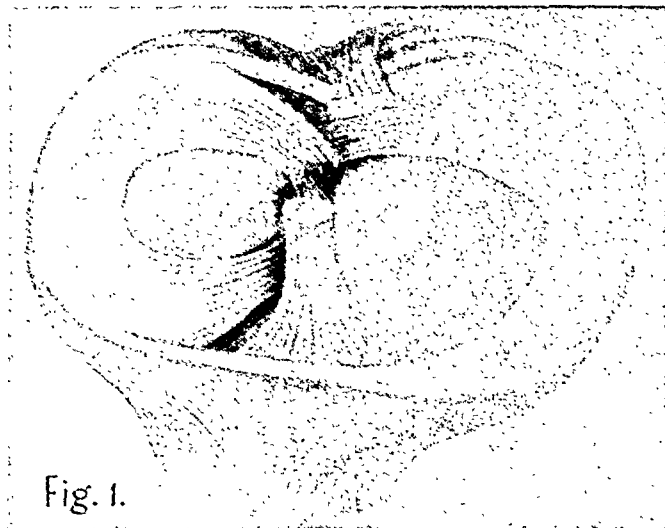


FIG. 1. Proximal end of the right tibia, showing the normal arrangement of the semilunar cartilages. The cruciate ligaments are also shown.

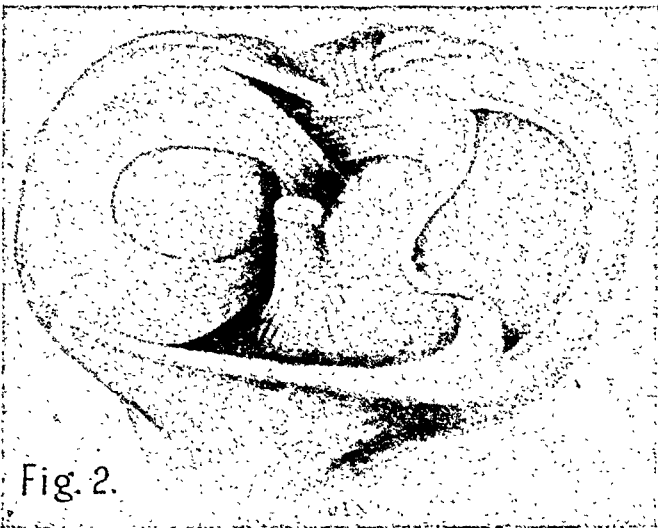


FIG. 2. Rupture of the internal semilunar cartilage. This is a rather common "bucket handle" type of rupture.

articulating surfaces and produce a block in the same manner as a displaced portion of meniscus. They are usually but not always demonstrable on x-ray examination.

#### PATHOLOGY

In four of the 112 cases which were explored no demonstrable tear was found at operation. In these four the cartilages were thought to be hypermobile. Of the remaining 108, medial cartilage tears were found in ninety-four, and lateral cartilage tears in ten. Both cartilage tears were involved in the same knee in the remaining four. Ten additional cases explored with the discovery of no demonstrable pathological condition are not included in this study.

The cartilage may split in any direction; longitudinal, transverse or oblique. Its structure is fibrocartilage and the fibers run in the longitudinal direction. (Fig. 1.) Naturally this is the most common direction of tear. (Fig. 2.) The various types of rupture are chiefly of academic interest, as the treatment is essentially similar, regardless of the location or type. Most injuries probably begin as a longitudinal split or "bucket-handle" tear. As further trauma is added the displaced portion breaks loose at one end and it becomes a free tag.

Cysts were found in three of the lateral cartilages explored. The degenerative

changes associated with these cysts apparently predispose to rupture of the cartilage.

#### TREATMENT

In the great majority of cases, operation is advised as soon as a definite diagnosis of cartilage tear is made. In a few mild cases conservative treatment may be given a period of trial. Our experience does not coincide with that of Zimmerman who restored twenty-six of thirty-one cases diagnosed as semilunar cartilage injuries to normal after one month of plaster immobilization.<sup>17</sup> In general, we are less aggressive in dealing with the following types: (1) Recent cartilage injuries whose signs suggest a small tear. A few of these will become symptom-free on conservative treatment. (2) Patients with a longer history who have adjusted satisfactorily to the condition, especially when obesity or arthritis is a complicating factor. We have established a definite rule never to operate on a patient who gives a history of old injury who shows no quadriceps muscle atrophy. This is particularly applicable to military personnel.

#### OPERATIVE PROCEDURE

The leg is shaved the morning of operation and not twenty-four hours previously as is so commonly recommended. It is



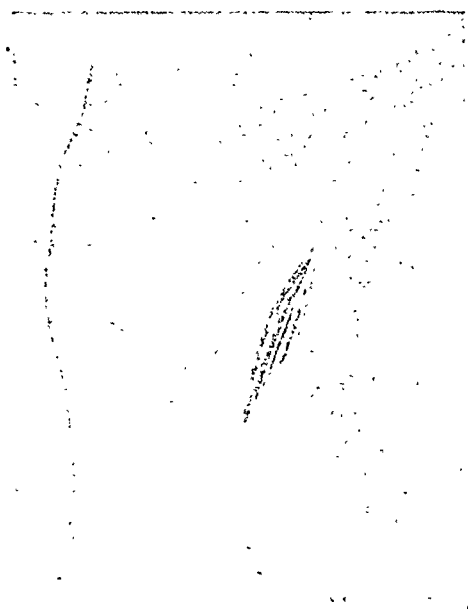


FIG. 3. The approach to the knee joint is through the oblique incision shown above. Adequate exposure is obtained for exploration.



FIG. 4. The ruptured internal semilunar cartilage has been freed anteriorly and the dissection is being continued past the internal collateral ligament. The collateral ligament is being held back by the retractor.

scrubbed thoroughly with soap and water followed by ether. The skin is then clean and healthy at the time of operation, in contrast to the irritated skin frequently seen after twenty-four hour preparations. A low spinal anesthetic is administered with 1.3 cc. of metycaine. A tourniquet is applied at the mid-thigh. The skin is then painted with two complete applications of merthiolate. The patient is placed on the operating table in such a manner that the knee can be flexed to 90 degrees in the course of the operation. For derangements of the internal cartilage an oblique incision two and a half inches in length is made on the anteromedial aspect of the knee. (Fig. 3.) It is made on a line running from the tibial tubercle to the adductor tubercle on the medial condyle of the femur. It does not extend as far as either of these landmarks. It is so placed that one-third of the incision is below the joint line and two-thirds is above. The capsule of the knee joint and the synovial lining are divided in the line of the incision. If the lateral cartilage is to be explored, a

similar type of incision is used but placed anterolaterally. Where it is desirable to explore both cartilages, both medial and lateral incisions are made. The period of convalescence is not appreciably increased by the additional incision and this method of exploration is thought to be definitely superior to the large exploratory incisions so much used in former years. The synovial fluid is aspirated by means of the Frazier suction apparatus. Preliminary inspection is made and the knee is flexed. The condition is noted, using gentle retraction and manipulation of the knee to facilitate exposure. Even in those cases in which no pathological condition is evident, it is our policy to excise the suspected cartilage. Slocum and Moore state that it is better to excise a normal cartilage than to risk overlooking a posterior tear.<sup>18</sup> It is generally recognized that such a procedure is not attended by any more residual disability than occurs with simple arthrotomy. In most cases we attempt to remove the entire cartilage as nearly as possible. The anterior horn is freed first. By sharp dis-

section the cartilage is separated from its peripheral attachment to the joint capsule as far posteriorly as possible. (Fig. 4.) The posterior horn can frequently be exposed and removed by manipulating the cartilage to the center of the joint. In rare cases of bucket-handle tears the periphery of the cartilage is not removed. If it is allowed to remain, it must be perfectly smooth with no rough fringes. After the cartilage is removed, the synovial cavity is flushed with ether and closed with a continuous suture of fine atraumatic chromic catgut. The tourniquet is removed and all bleeding vessels tied off. The remainder of the wound is closed in routine fashion. We do not practice the injection of air postoperatively as advocated by Bohlman.<sup>19</sup> Pressure is applied with an elastic bandage extending from the base of the toes to above the knee.

Postoperatively no immobilization is considered necessary. Motion is encouraged immediately. For five minutes out of each waking hour after the first day, active quadriceps exercises are insisted upon. This is probably the most important single factor in securing an early return to normal function.

In this series there have been three minor skin infections. There has been no incidence of deep-seated infection within the joint. A very occasional case has had an accumulation of serous fluid which required aspiration postoperatively. Usually the patient is allowed in a wheel chair on the third to the fifth day and is allowed to walk on the seventh to the tenth day.

#### PROGNOSIS

The prognosis following removal of the knee joint meniscus is excellent and a rapid return to ordinary activity can be anticipated. The average civilian is able to adjust his activities in such a way that a small amount of disability even if prolonged is of little consequence. This statement cannot be applied to military personnel. When a military man returns to duty, he is expected to do hard physical

labor. Many of our Coast Guard patients were returned to duty in six or eight weeks. On the other hand some required longer periods especially when assigned to sea duty on amphibious landing craft. Six required assignment to light duties for intervals of six to twelve months. Two required medical discharge from the Coast Guard. The report of Hamilton and Finkelstein<sup>20</sup> is of interest. Ninety-four per cent of their soldiers were returned to full duty usually in six to eight weeks; 4 per cent were assigned to limited duty and 2 per cent were discharged from the Army. These figures are much better than can usually be attained and late follow-up studies on this group would be very valuable. It is possible to prophesy with reasonable accuracy which patients will have a prolonged convalescence. This can be taken into consideration before operation is advised on certain types of cases.

Early improvement but delayed return to regular duties is expected where the following conditions exist: (1) Extensive quadriceps muscle atrophy, especially when the injury is a year or more old. These patients complain of weakness and instability in the affected knee postoperatively. Eventual recovery is usually complete or almost so but may require many months. (2) generally weak musculature with relaxation of the knee joint; (3) marked overweight; (4) other disease of the knee joint. We have encountered a marked osteochondritis dissecans in two cases which were explored and found to have a cartilage injury. These patients gave a history of long-standing difficulty. It seems possible for either of the two conditions (cartilage injury, or osteochondritis dissecans) to be primary and contribute to the other. Other cases of osteochondritis dissecans not associated with cartilage disorders have been encountered but are not included in this study. Arthritis not only increases the period of convalescence, but may also simulate very closely the clinical picture of a cartilage injury. Some of the most difficult cases from a diagnostic standpoint

are those with a history of injury, atypical physical findings and arthritic changes visible in the roentgenograms. We do not like to explore an arthritic knee for a cartilage injury unless a classical picture is present, since future disability from arthritis is frequently blamed on the operation. On the other hand, if there is a cartilage injury, the arthritic patient is in greater need of surgical treatment than one without this complication. Unless removed, the damaged cartilage will aggravate the disability from his arthritis.

#### SUMMARY

1. Our experience with 126 cases of suspected semilunar cartilage injuries is reviewed; 112 patients in this group were operated on and the diagnosis was confirmed in 108.

2. The diagnosis can be made with a high degree of accuracy and is based largely on the history and physical examination. X-ray is chiefly of value in ruling out other diseases of the joint.

3. If untreated, cartilage injuries lead to chronic disability. The treatment is excision of the damaged cartilage. The operation is simple and does not lead to impairment of function. The period of convalescence is short, and a return to normal activity may usually be expected in from four to six weeks. Where quadriceps atrophy is pronounced or other disease is present, the period of disability following operation may be increased.

4. Early operation is advised on all but a few carefully selected cases of cartilage injuries.

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# MAXILLOFACIAL INJURIES\*

## RECONSTRUCTIVE SURGERY OF THE DEHISCENT PAROTID DUCT AND DEHISCENT PERIPHERAL FACIAL NERVE

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THE purpose of this article is fourfold: (1) To bring up to date the work done on parotid duct injuries; (2) to review the literature to date on the associated facial nerve injuries; (3) to report a case, and (4) to present a logical surgical technic in the repair of maxillo-facial injuries resulting in lacerations, obstructions or dehiscences of the peripheral facial nerve and parotid duct.

The latter premise is predicated upon the following principles: (1) Conservation of the parotid gland by restoration of the traumatic dehiscent or fistulous duct by end-to-end anastomosis; (2) preservation of the dehiscent traumatic peripheral facial nerve by inlay nerve graft using the principle of the Bunnell pull-out suture, and (3) end-to-end anastomosis of nerve twigs using the principle of the Bunnell pull-out suture.

Reconstructive surgery in maxillofacial injuries aroused great interest on the part of the surgeons during and subsequent to World War I but greater impetus has been given to the subject since and during World War II.

A great variety of traumatic injuries about the face, including fractures, lacerations, burns and avulsions with or without subsequent infection occur in ordinary life. In civilian practice, while such injuries are not as common as they are on the battlefield, similar injuries are never the less frequently encountered. Such injuries arise in the normal course of life as a result of automobile, aeroplane, elevator and train accidents, explosions, falling missiles and from knife and bullet wounds and other acts of felony.

In lacerations about the face there are two kinds: linear, which may be vertical, horizontal or diagonal, and multiple which may be vertical, horizontal or stellate. As to degree there are first, second and third degrees. The first is through the skin and subcutaneous tissues and involves no important structures; the second is through the skin, muscles and vessels with the preservation of important structures in whole or in part. These are termed wounds of the simple type. The third involves the skin, muscles and vessels with injury to any or all important structures as well as exposure of bone, glands, ducts, organs or mucous membrane. This is termed a complex or compound wound. In vertical or stellate lacerations of the face, injury of ducts or nerves is more likely. In penetrating wounds, trauma to the duct and nerve, that is the facial nerve, and parotid duct is determined by the level of the injury. The facial bones as the zygoma, the nasal bone, the orbit, and the mandible protect the duct and facial nerve except in the second or third degree injuries. The duct and nerve are less apt to be injured in horizontal wounds.

In third degree lacerations, associated fractures of contiguous bones may exist, either simple, compound or impacted or comminuted into the antrum, ethmoid, orbit, mouth or nose or cranial vault.

*One of the least commonly stressed injuries about the face is parotid duct injury, particularly when the injury results in the dehiscence of the duct.* Such an injury would necessarily be predicated upon a similar injury to the peripheral facial nerve. This paper deals primarily with

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the secondary repair of the dehiscant parotid duct, dehiscant zygomatic branch of the facial nerve and repair of the buccal branch. The technic employed is one that can be utilized in either primary or secondary repairs.

The primary considerations in traumatic wounds, involving the duct proper, and peripheral facial nerve are: (1) *Type of injury*. Is it a cutting wound? Is it a tearing or avulsion wound? Is it a direct impacted wound complicated by fracture, or is it a bullet wound or a burn wound? (2) Is infection present or infection likely? (3) Is the surgery immediate or delayed? (4) Is there an oral or external fistula present? Or a blind fistula? Or an obstructed duct? (5) Is facial paralysis immediate or delayed? (6) What are the x-ray findings? Do they reveal fracture, comminution of mandible or maxilla or do they reveal subcutaneous pooling of lipiodol when injected through Stenson's duct? Do they reveal obstruction of the duct? (7) Is parotitis present? (8) *The age of the patient*: surgical intervention would vary considerably depending on the age. In infancy, the repair of the peripheral facial nerve would be virtually impossible owing to the size of the filaments. The duct, on the other hand, while delicate to repair could be done satisfactorily.

Previous to immediate or delayed surgery on the parotid duct and peripheral facial nerve, it is advisable to secure a complete history of the case and complete work-up from an x-ray and neurological viewpoint. A longstanding parotid duct injury, without fistula and with obstruction, due to previous inflammatory processes within the wound, would cause parotid gland atrophy. In such a case, surgery should not be delayed unless frequent aspiration of the duct is made to decompress the gland. Where there is sealing off by obstruction to the proximal portion of the duct with swelling and distention as in the author's case, lipiodol studies are best made by injecting lipiodol

into the distended duct or sac. Similar considerations must apply to injuries of the facial nerve which might result in permanent paralysis due to avulsion or neuroma about the nerve endings. From a neurological standpoint, the reaction of degeneration may be ascertained by electric stimulations. Immediate x-ray studies, following injury, will be limited to the diagnosis of an existent fracture or fractures.

In the simple cases, x-ray studies with lipiodol injected through Stenson's ostium will usually locate the lesion or lesions in the parotid duct if obstruction exists. If dehiscence is present, pooling of the lipiodol will be revealed in the subcutaneous tissues providing the distal portion of the duct is not closed over. If fistulas are present, the condition of the parotid gland and duct tributaries cannot be readily visualized.

Since this paper deals with the delayed reconstruction in duct and nerve injuries, reference will be made to important points relevant to the surgical repair in delayed cases, and also to repair in the primary cases and an analogy between the two emphasized.

The first and foremost consideration is the anatomical resection and mobilization of the injured parts layer by layer. Other considerations are: Resection of all scar and other pathological tissue; the identification of normal proximal and distal duct ends; the identification of corresponding normal proximal and distal nerve branches bordering the dehiscant area; suturing of the ends of the dehiscant duct with vertical mattress sutures with indwelling non-absorbable dowel, in this case No. 30 steel alloy wire; and the insertion of an inlay nerve graft in the dehiscant portion of the zygomatic branch of the facial nerve and suturing same in place with a pull-out suture.

#### CASE REPORT

Mrs. A. E., a white female, aged twenty-eight, entered the Morrisania City Hospital on



FIG. 1. Front view photograph of patient six weeks after injury and two days before plastic correction.



FIG. 2. Front view of patient six months after plastic surgery.

January 20, 1944, as an emergency case suffering from lacerations of the right face following an automobile accident in which she was thrown through the windshield. The main laceration extended from a point below the tragus along the zygoma for a distance of about 3 cm. thence to the chin at approximately the crossing of the external maxillary artery. Right facial paralysis was present. Primary surgical repair of the wound was done on January 20th, the day of the accident.

Subsequently, the patient developed a swelling of the right side of the face and there was loss of sensation over the right side of the face and a partial facial paralysis with absence of secretion from Stenson's duct. The patient remained in the hospital until March 1st with no apparent improvement in recovery of the facial paralysis, in recovery of secretion from Stenson's duct, in recovery from the anesthesia of the right side of the face or in reduction of swelling. Moreover, there was a gradual and progressive swelling of the right cheek accompanied by bluish discoloration. X-ray studies with lipiodol injected through Stenson's duct

revealed pooling of the lipiodol in the tissues of the cheek on the right side with evident injury by trauma to the duct itself. On March 1, 1944, the patient was transferred to the plastic surgery department for further study and care. A review of the x-ray and consultation findings was done. From these it was apparent that there was obstruction to the right parotid duct and right facial paralysis was present.

From the ostium of Stenson's duct, no secretion could be obtained. Exploratory operation with an attempt at plastic repair was done on March 3, 1944. The physical findings at this time revealed a well nourished, white female, ambulatory in the ward, not in acute pain and suffering merely from right facial paralysis, edema and distortion of the right cheek. Her temperature was 98.6°F., pulse 76, respiration 20. Parotid secretion was obtained from the ostium of the left Stenson's duct but none from the right. Probing of Stenson's duct on the left, using a whale bone filiform guide 1 mm. in diameter, passed for a distance of  $2\frac{1}{4}$  inches. On the right side, the guide passed

for a distance of  $\frac{5}{8}$  inch. The left side of the face was symmetrical. The right side was asymmetrical from the angle of the jaw on the right side to a point on the level with the outer canthus of the right eye. There was a pyramidal-shaped swelling most prominent below the zygomatic process of the temporal bone. The parotid gland was not palpable. A healed scar was present extending from the facial attachment of the tragus to a point  $1\frac{1}{4}$  inches forward and thence downward in the direction of the right commissure of the mouth for a distance of about 3 inches. This scar showed evidence of widening and thinning out in some areas due to distention and pressure from beneath.

On palpation, there was an alternating firmness and cystic feel to the mass. Bordering the scar, there was a bluish, translucent hue in the thinner areas.

Neurological examination at this time revealed an inability on the part of the patient to draw the angle of the mouth laterally or upward on the right side. Grimacing motions with the right cheek, lips and nose could not be made. Attempt to whistle was abnormal. The innervation of both eyelids was equal although the right upper eyelid contracted with less power than the left.

*Interpretation:* Right peripheral facial paralysis involving the buccal and zygomatic branches. Temporal branches of the facial nerve apparently intact with no apparent differentiation in the symmetrical motions of both eyes and the forehead except a slight difference in the ability to raise the right upper eyelid.

It was found that the parotid duct had been severed and had undergone a pathological change in its central portion. The duct was probed from the buccal side using a nasolacrimal probe, size No. 00. The probe entered the duct for a distance of  $\frac{1}{2}$  to  $\frac{5}{8}$  inch. The buccal portion of the duct through the buccinator muscle was severed and had healed with scar tissue. The central portion of the duct over an area of about  $1\frac{1}{2}$  inches was involved in an inflammatory mass of edematous mucous membrane and periductal and ductal tissue. This tissue involved the subcutaneous tissue of the cheek of the right side extending as far as the zygomatic process of the malar bone superiorly and posteriorly involving the anterior border of the parotid gland, and inferiorly the inflammatory process was contiguous with the muscle fibers and fascial

insertion of the masseter muscle. On excising this mass of inflammatory tissue the parotid duct was liberated as it made its exit from the parotid gland. The length of the duct stem at its exit from the parotid portion of the parotid gland was about  $\frac{3}{8}$  inch. The dissection completed the dehiscence between the parotid portion and the buccal portion of the parotid duct measured between  $1\frac{1}{4}$  and  $1\frac{1}{2}$  inches. During the dissection, it was found that the buccal and zygomatic facial branches had been severed at the level of the anterior border of the parotid gland. The peripheral branches were caught up in an inflammatory mass involving the masseter tendons. The proximal portion of these two branches were isolated at the margin of the parotid gland. The dehiscence between the end of the severed zygomatic peripheral branch of the facial nerve above mentioned amounted to  $1\frac{1}{4}$  to  $1\frac{1}{2}$  inches.

The operation was carried out under local procain anesthesia blocking the infraorbital, maxillary and mandibular nerves. Additional procain infiltration was given superficially in the subcutaneous tissue and about the scarred area. A No. 00 nasolacrimal probe was inserted into the oral portion of the parotid duct and held in position with a silk suture. The surgical incision was made by first paralleling the scar deformity in its entire direction superior and anterior to the scar.

A second incision paralleling the first was made inferior to the scar. The dissection extended down into the subcutaneous tissues of the right cheek through and into the parotidomasseteric fascia which was reflected as a separate layer. The diseased portion of the parotid duct and periductal tissues was excised by sharp dissection. The masseter muscle was dissected free of the inflammatory mass. The buccal portion of the parotid duct was liberated free as far as the submucous extension, and the lumen exposed by resection of the closed end. The parotid portion of the parotid duct was liberated and then a No. 30 alloy steel wire was passed through the ostium of Stenson's duct into the surgical wound, bridging the dehiscence of the parotid duct, and then passed into the parotid portion of the parotid duct. The continuity of the parotid duct was then established by placing five size .004 silk mattress sutures through the perimucous tissues of the duct proper. These sutures were drawn uniformly taut, then a



FIG. 3. X-ray photograph showing pooling of lipiodol in obstructed and dilated parotid duct seventeen days before plastic correction.

No. 2 silk mattress suture was placed incorporating the buccal soft tissues and the parotid fascial tissues and tied firmly. This relieved the tension of the severed tissues. The five silk sutures were then drawn gradually and simultaneously taut, each with a single knot with the help of two assistants. The sutures were further secured with two additional knots each. The duct continuity was restored and the indwelling wire dowel could be easily felt establishing the continuity of the lumen. The repair of the peripheral branches of the facial nerve was done, with a Bunnell pull-out suture of Deknatel, size .004, approximating the distal portion of the injured buccal nerve with its proximal portion. The cut ends of the zygomatic portion of the nerve could not be approximated in this way owing to the dehiscence even though an attempt was made to mobilize the branches. Therefore, the lower skin flap was reflected downward and a section of the inferior branch of the cervicofacial nerve was excised measuring 30 mm. in length. This section was placed between the proximal and distal branches of the dehiscence zygomatic branch of the facial nerve. This nerve graft was held in place with the use

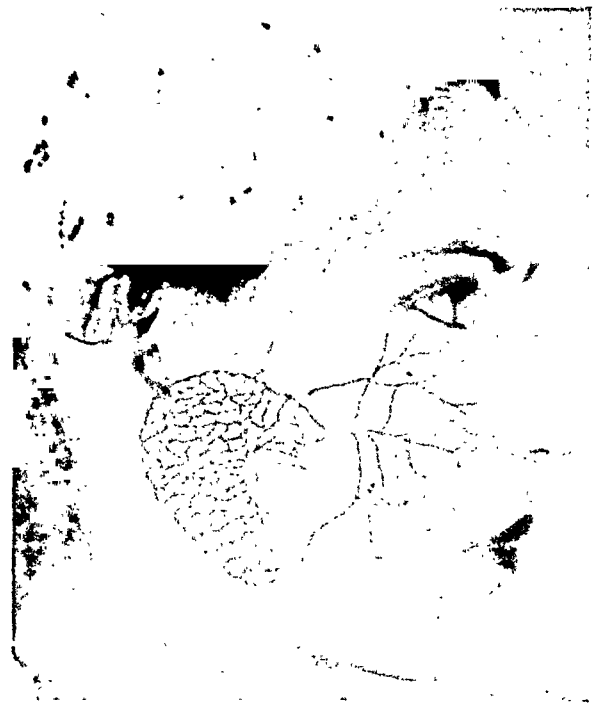


FIG. 4. Photograph of drawing to show anatomical relations of dehiscence parotid duct, zygomatic nerve branch and severed buccal branch.

of a Bunnell pull-out silk suture, carried through the anterior surface of the cheek through the subcutaneous tissues, through the peripheral branch of the nerve across its trunk in an undulating fashion, threading the graft into place end-to-end with the proximal and distal nerve branches so as to form one continuous chain of nerve tissue. Posteriorly the silk suture was carried out through the posterior portion of the cheek. The No. 2 silk tension approximation suture was removed. The soft tissues were approximated over these grafts and the duct and the fascial edges of the parotidomasseteric fascia were sutured and then the soft tissues of the cheek and the skin were approximated with a running subcuticular suture of No. 35 steel alloy wire. A folded No. 2 silk suture was placed through the lower portion of the wound to act as a drain. The steel wire dowel through the parotid duct was carried through the external surface of the cheek at the level of its exit from the parotid ostium. An external head dressing and cheek dressing were applied.

#### ANATOMICAL REVIEW

From Gray we learn that "There are three pairs of salivary glands, the largest, the parotid gland. The gland lies immediately below and in front of



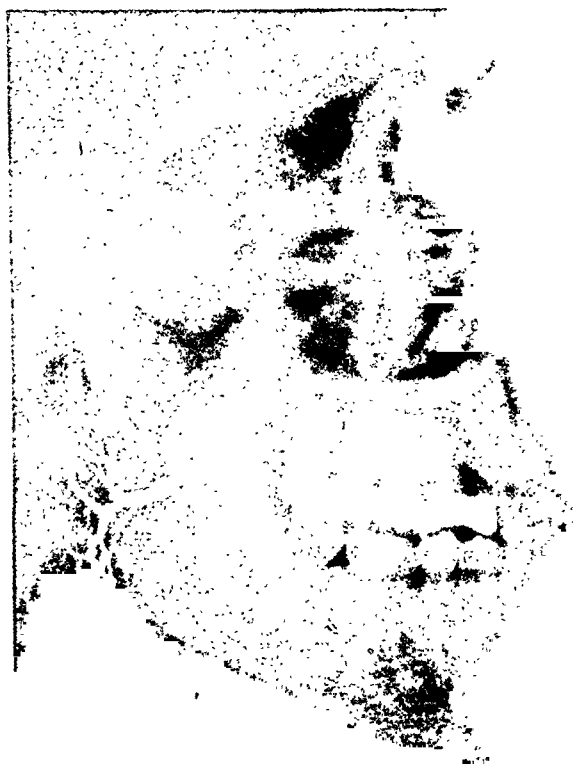


FIG. 5. Lateral x-ray photograph demonstrating with lipiodol the reconstructed duct and normal duct tributaries of parotid gland two months after plastic surgery correction.



FIG. 6. Front x-ray photograph two months after plastic surgery demonstrating distribution of lipiodol in duct and tributaries.

the external ear. The parotid duct begins by numerous branches from the anterior border of the gland, crosses the masseter muscle and at the anterior border of this muscle turns inward nearly at a right angle, passes through the corpus adiposum of the cheek and pierces the buccinator muscle. It then runs for a short distance obliquely forward between the buccinator and mucous membrane of the mouth and opens upon the oral surface of the cheek by a small orifice opposite the upper second molar tooth. While crossing the masseter muscle it receives the duct of the accessory portion. *In this position it lies between the branches of the facial nerve; the accessory part of the gland and the transverse facial artery are above it. The duct proper is about 7 cm. long.*"

J. McCormack, in discussing the surgical anatomy of the facial nerve states: "While injury to the facial nerve is not vitally

damaging, the resultant cosmetic deformity brings great psychic distress to the patient." He further states that many authors have discussed the surgery and pathology of the parotid area but relatively little had been written about *the exact relation of the gland to the facial nerve*. His studies were based upon one hundred anatomical specimens at the anatomical laboratories of Northwestern University Medical School. His studies reveal the following: Of the two principal divisions of the facial nerve the temporo-facial portions supplying the upper portion of the face is by far the larger; however, the temporal, zygomatic, buccal, mandibular and cervical rami named on the basis of region supply, were always identifiable. Within the substance and close to the border of the parotid gland, the nerve fibers of the facial nerve were, relatively speaking, of considerable caliber,

diameter approximately 2 mm. Further observations made by McCormack were that the zygomatic ramus, which often includes *the buccal supply, courses transversely across the face just above the parotid duct, often crossing it.*

McCormack concluded that there was an intimate relationship between facial nerve and parotid gland, that the buccal branch is somewhat superior to the main trunk of the nerve (by a finger breadth or less commonly) and, even when the superficial lobe of the gland is prolonged forward, this branch is likely to be exposed just beyond the parotid tip. It regularly overlies the parotid duct.

#### REVIEW OF CURRENT LITERATURE

The most comprehensive review on the work on parotid duct was made by Cristaferson, Ajalet and Gradman, in an article written in 1943. They stated, "In reviewing the literature, we find that only five successful repairs have been reported. It is perhaps significant to note that the first case was reported by Dr. Tees in 1926. He used catgut as a dowel in the duct and left the end projecting in the mouth. He then approximated the ends of the duct with two fine interrupted catgut sutures passed through the sheath around the duct."

In 1927, Dickinson used the same technic but used silkworm gut for a dowel. However, the suture fell out in two days. Black and Flagg, in 1928, used a small ureteral catheter as a dowel and left one inch projecting into the mouth and fixed it by interrupted linen sutures around the opening of the duct. The catheter was removed on the ninth postoperative day.

Butler and Guinan, in their article written in 1933, reported an injury to the parotid duct occurring in a similar manner to the author's case, namely, by shattering windshield glass while in an automobile accident.

In their report, the above authors cited the case of a twenty-seven-year old

girl who had been in an automobile accident and had received lacerations of the face, the most prominent one, extending from the inferior angle of the mandible straight upwards in front of the tragus. Preliminary to the discussion of the repair which was used, they stated, "The parotid gland, the branches of the facial nerve and masseter muscle were severed. *The severed nerve fibers were too small to warrant repair.*" The repair was done four hours after the accident. The duct lacerations were at the outer border of the masseter muscle. They used a ureteral catheter. They admitted that secretions came through the lumen and also admitted making an incision on the buccal mucosa opposite the line of anastomosis of the severed duct to facilitate drainage in case of consequential strain on the suture line. Their method of repair simulated the method of repair in this author's case. However, after identification of the cut ends of the duct, they described a "horsehair" suture as being placed in the lumen of the proximal end for a distance of an inch, the other end being placed through the lumen of the distal end of the duct into the mouth. They proceeded to approximate the cut ends of the duct with interrupted black silk, passed through the sheath around the duct. Catgut sutures were used to close the soft tissue in layers and interrupted silk for the skin. The "horsehair" dowel was fixed to the external skin by adhesive bringing it out through the angle of the mouth. They removed the dowel on the seventh postoperative day. The above authors advised the use of silk or any other non-absorbable material as a dowel to avoid tissue reaction and subsequent stricture of the lumen of the duct.

Brohm and Bird, in an article written in 1935, stated that since 1926 three articles had been written emphasizing the importance of immediate suturing of the severed parotid duct. They further stated that the literature prior to 1926, was strangely silent on the subject of

primary anastomosis, that most articles, which appeared following World War I, concerned themselves primarily with the problems of control of the fistulous discharge and secondary repair. Inasmuch as most war wounds were usually ragged and extensive and usually contaminated, it was impracticable to attempt primary repair. Brohm's and Bird's method of repair of the severed duct was facilitated by the use of a filiform bougie dowel which was anchored by passing it from the mouth through the cheek and suturing it securely to the skin at the point of exit.

In the specific case report in this article, the passing of the No. 30 steel alloy wire through the cheek and looping it externally into the skin simulates Brohm's procedure.

Brohm's and Bird's case was reported in 1934. In their case report no mention is made of facial nerve injury and no mention is made of either dehiscence of the duct or the nerve. The duct was severed at the portion which bends sharply around the masseter muscle and the anastomosis of the severed ends was accomplished with the use of interrupted silk sutures on French eye needles. Here again French eye needles corresponded with the needles used in the author's case. Brohm and Bird established five general principles in the repair of duct injuries: (1) early repair, (2) careful hemostasis, (3) an anchored dowel of non-absorbable material, which would not swell and which was sterilizable, (4) the use of silk for the repair of the duct, and (5) closure of the wound anatomically without drainage. In their summary, they see no reason for the use of a dowel with a lumen inasmuch as most of the saliva would pass between the dowel and mucous membrane and the use of too large a dowel might obstruct the duct.

F. J. Tees, in 1926, emphasized the fact that immediate repairs of the divided parotid duct received scant notice in the literature and if primary repair is mentioned with the salivary duct injury, it is usually in the form of advice as to the

search for the divided ends of the duct. The following is a direct quotation from Tees' article:

"Once the fistula has developed, no method aiming at its cure seems to guarantee success and *as a counsel of despair not a few in the obstinate cases advocate complete excision of the parotid gland*. It is possible that the lack of attention to the painstaking method of accomplishing this primary union is responsible for the larger number of cases which develop fistulae and require subsequent operation." Tees classifies the treatment of fistulas into two main divisions: the first of which is the restoration of the normal aqueduct and the second aims at the conversion of an external into an internal fistula.

In Furstenberg's article in 1945, he stated: "Reconstruction of the facial nerve from the point of view of the otologist implies a restoration of its function by surgical means. In the main, two procedures are advocated: *the grafting of a nerve transplant and an end-to-end anastomosis*."

The first is a plea for the preservation of the facial nerve and, second, a recommendation that the end-to-end anastomosis be used if practicable when the nerve is injured beyond its ability to recover spontaneously.

What happens to the facial nerve when it is severed? The distal end degenerates over its entire extent, but the proximal end keeps on growing. The nerve fibers push forward, and if they meet resistance in granulation tissue, they criss-cross, wrap around each other in spiral fashion and grow otherwise in an inordinate arrangement to form what is termed a neuroma. If, however, one gives the neuraxes the pathways along which they may grow and prevents or removes any resistance to their progress, the end result is a complete regeneration of the nerve. It has been estimated that the average rate is probably a millimeter a day.

It goes without saying, therefore, that the end-to-end anastomosis offers less risk than the grafting of a nerve transplant and should be employed whenever practicable. The fresh ends of the severed nerve are brought together with avoidance of rotation so that the down growing neuraxes will extend distally within the neurilemma sheaths of the degenerated nerve. Care must be taken to approximate the nerve sheath so that no crevice will remain at the joint which will permit ingrowth of granulation or connective tissue.

The budding neurofibrils find little resistance to their growth and progress throughout the nerve transplant. A successful technic in using a nerve transplant embraces the following principles: (1) The introduction of the transplant in direct line with the proximal and distal ends of the cut nerve; (2) the avoidance of angulation and torsion, and (3) a clean wound, "infection frustrates repair."

Bunnell wrote in March, 1937, "In man, the main function of the facial nerve is motor, for emotional facial expression. The nerve has, however four other functions: taste, in the anterior two-thirds of the tongue; secretory, for saliva and tears; and deep visceral sensibility, especially of the soft palate."

Repair by anastomosis with other nerves is now obsolete, as it does not restore emotional facial expression and dissociated movements occur. Present indications are either to repair the facial nerve directly, by decompression, suture or free nerve graft; or, if the nerve is irreparable or the facial muscles have undergone degeneration, to perform a plastic reconstruction operation using muscle and fascia.

The nerve ends are accurately sutured together with four stitches of the finest silk, using the shortest curved eye needles. Suture or graft obliterates all dead space and maintains the growing nerves surrounded by clean and vascular tissues, at the same time aiding in degree of perfection of their union.

The repair of this nerve should be good for three reasons: The lesion is well out in the periphery, where regeneration in the nervous system is best. The nerve is practically a pure motor one when it is repaired, with the exception of the chorda tympani, and a pure nerve regenerates better than does a mixed one, as sensory axons are not lost growing down motor pathways and vice versa. Also, the nerve is small, which allows its free ends to obtain sufficient nourishment from lymph without central necrosis until new vascularity is established. In these three respects the facial nerve resembles the small nerves in the hand, suture of which yields usually good results.

Free grafts of small nerves are highly successful, full thickness of the graft being nourished in the surrounding lymph until it is restored by revascularization, thus avoiding the inevitable central necrosis which occurs. In several cases, the nerve branches were sutured as far distally as the anterior border of the parotid gland. Here the branches are fine, but if a nerve twig is not too fine to suture it will regenerate.

When a motor nerve twig is cut very distally, as about the eye or mouth, resulting in a small patch of paralyzed muscles, excision of the scar followed by a good coaptation of the severed edges of the muscle plane will result in some degree of reactivation of the paralyzed patch of muscle, as the peripheral branches of the nerve have a tendency to regenerate.

Bunnell concludes that, nerve tissue should be sutured to prevent contracture when used as a graft. Nerve tissue contracts just as skin contracts when cut. This phenomenon is true of all soft tissues, particularly when they are sectioned in vivo.

#### RÉSUMÉ

In retrospect, duct injuries have, for the most part, been considered quite separately with respect to methods of repair and these usually have been em-

phasized under two headings: (1) the immediate repair, and (2) repair of the duct with existing fistulas. With reference to the seventh nerve peripheral injuries these, too, have been considered for the most part as separate entities, notably by Furstenberg and Bunnell.

With reference to Butler and Guinan's article in 1933, it is apparent that the catheter obstructed the lumen and it is quite possible that a fistulous opening alongside of the ostium was responsible for the successful repair of the wound inasmuch as no mention is made of the observation that secretion was coming from the ostium. No mention is made of nerve injury or repair and it is possible that the horizontal wound in their case did not sever the nerve branches as is so common in the vertical wounds. Dr. T. G. Blocker recently stated that in the maxillofacial injuries in World War II involving the parotid duct, the ducts were repaired by conversion into internal fistula and peripheral facial nerve branches nearly always regenerated spontaneously.

In all the above case reports no mention had been made of the study of the tributary distribution to the parotid duct with lipiodol and x-ray.

It is the contention of the author that, while many cases of separate injury of the duct and facial nerve exist in consequence of injuries of a type, it is more than likely that if parotid duct injury exists peripheral nerve injury is also present and vice versa. If a lacerating, penetrating or avulsion injury involves the parotid duct, the buccal and zygomatic branches of the facial nerve will be involved.

Further from the successful secondary repair by primary suture and graft exemplified in this case, the author believes that it is not necessary to convert external fistulas into internal fistulas as a method of repair, and believes that it is practicable to explore, isolate, resect and anastomose by primary suture as a method. That is better surgery in view of the nerve factors present. The author's case, after pathologi-

cal resection and excision forty-three days subsequent to the primary injury, was successfully repaired despite the existence of a 30 mm. dehiscence in the duct proper and a 30 mm. dehiscence in the zygomatic branch of the facial nerve. The use of an indwelling No. 30 alloy steel wire dowel, which can be carried out through the cheek with no residual evidence of a puncture wound externally, creates a new dowel material as well as supplying a dowel unsurpassed in capillary and surface tension factor. The successful repair of the above case should nullify the opinions of those who elect to extirpate the parotid gland or destroy the gland by radiation when obstruction or fistulas exist.

With reference to the nerve injury successful repair by suture and inlay nerve graft with the use of a Bunnell pull-out undulating suture, is a practical means of reinnervation and regeneration of the peripheral branches of the facial nerve when involved. Contrary to many of the opinions expressed, the nerve twigs in the area anterior to the parotid gland measure approximately 1 to 1½ mm. in diameter and by careful suture and inlay grafting successful repairs can be obtained. The method used in the author's case in which the dehiscence existed was to tie a B silk suture around the proximal and distal nerve endings to obtain the shortest diameter and a direct line continuity between the nerve endings. The next step was to resect one of the peripheral twigs of the cervicofacial nerve branch equal in length to the dehiscence area and lay the graft alongside of the the silk tract. A Bunnell undulating pull-out suture was threaded through the distal end of the severed nerve, then through the graft and thence through the proximal end of the severed nerve. The silk link joining the severed ends was then removed and the nerve ends freshened by section. Where the approximation of the cut ends could be brought into continuity as in the buccal branch by mobilization from the perineural

tissues, a similar Bunnell suture was utilized to facilitate reinervation. The Bunnell suture is spliced through the central part of the nerve graft into the central part of the cleanly cut proximal and distal traumatized nerves. This method permits a short cut in the reinervation and reanimation of the muscles of the face and eliminates residual paralysis.

Dr. Paul W. Cohen interpreted the x-ray findings of the author's case after lipiodol injections, as a cystic encapsulated swelling most likely an obstruction of the duct. Otherwise, an exudation of the parotid fluid into the subcutaneous tissues would have caused a fistula after forty days. It is significant that no injection could be made into Stenson's duct through the natural ostium showing that the distal end of the duct had been fibrosed. An injection of methylene blue had been made into the swollen cheek to observe the existence of fistula along the path of the duct. No elimination of secretion by fistula was noted and the cheek continued to swell. Frequent aspirations controlled the swelling; as much as two ounces of saliva had been collected in a few hours.

The repair of external parotid fistulas by conversion into internal fistulas is an obsolete operation requiring no exceptional skill, is not anatomical, and is not comparable with surgical principles applied in general surgery in which the method of repair of fistulas is directed to the restoration of lumen continuity. Perhaps the neglect of parotid duct repairs is based upon the existence of six salivary glands so that when one gland or duct is put out of function only a proportionate amount of emphasis is placed upon its importance. However, the loss of the parotid gland, due to extirpation, because of obstruction, or atrophy from radiation therapy, will cause facial asymmetry and this is of paramount importance to the plastic surgeon, particularly when there is an associated peripheral nerve paralysis.

## CONCLUSIONS

1. In surgical injuries, involving the parotid duct and facial nerve, primary surgery should be instituted.

2. Primary surgery may not be adequate and secondary repair may be delayed as in the author's case as long as forty-three to forty-five days or longer if fistulas or obstruction exist.

3. In the presence of obstruction of the duct with progressive swelling as in our case secondary repair should not be delayed beyond forty days unless aspiration is done as aspiration will reduce pressure on the gland and prevent atrophy of the latter.

4. All post-traumatic swelling of the parotid gland must be differentiated from parotitis and hasty surgery must be avoided.

5. The inability to put more than one interrupted suture in small nerve twigs suggests the importance of the Bunnell splicing suture. In addition neurotization is not inhibited because the suture is removed in two weeks. The splicing suture makes for better union and is not apt to tear out when movements of the face are made.

6. Conservation of the parotid gland, despite the presence of an additional gland, is paramount in seeking a correct diagnosis and cure of the lesions. The preservation of the physiological function of the parotid gland in traumatic lesions, while difficult from the surgical standpoint, many times offsets undesirable extirpation and destruction by radiotherapy both of which become a subterfuge.

7. The choice of anesthesia is significant in the author's case, a maxillary nerve block with sedation provides anesthesia for several hours operating with no undesirable consequences to the patient. Under general anesthesia, the details of meticulous surgery would be difficult.

8. The use of the steel alloy wire provides an anchored dowel of non-absorbable material, which will not swell and which is sterilizable.

9. The importance of accurate anatomical closure by proper suturing cannot be too strongly emphasized. Also the use of diluted hydrochloric acid to stimulate functional secretion and thereby favor decompression of the obstructed gland is advised. Postoperatively, following discharge, the avoidance of drafts and cold breezes on the affected side for several months is of paramount importance.

10. Preoperative consultation and preoperative lipiodol studies and x-rays in comparison with the healthy side is necessary in all secondary cases.

11. Postoperative dilatation of the reconstructed duct facilitates drainage and prevents cicatrization about the suture line. This procedure should be instituted once weekly for a period of two months by the use of a filiform guide.

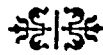
12. Postoperative follow-up is the only means of establishing the success of the operation and this implies the use of postoperative lipiodol studies.

Finally pre- and postoperative photographs are an indication of the success or failure of the case. Further motion picture studies are important in demonstrating the flow of the salivary secretion from the ostium of Stenson's duct following reconstruction.

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It must be understood that *routine wound excision has no place in facial surgery*. That same copious blood supply, which in face wounds is often responsible for profuse and even dangerous haemorrhage, will often ensure the viability of flaps almost completely detached and is responsible for the rarity of serious spreading infection. Gas gangrene is unknown.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams and Wilkins Company).



# LATE REPAIR OF MASSIVE TISSUE DEFECTS BY THE SPLIT SKIN-LINED FLAP GRAFT

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THE late repair of massive tissue losses with the flap graft method presented a different picture from no subcutaneous tissue. Most often the scar epithelium was right over bone, fascia, muscle or tendon. We now had a

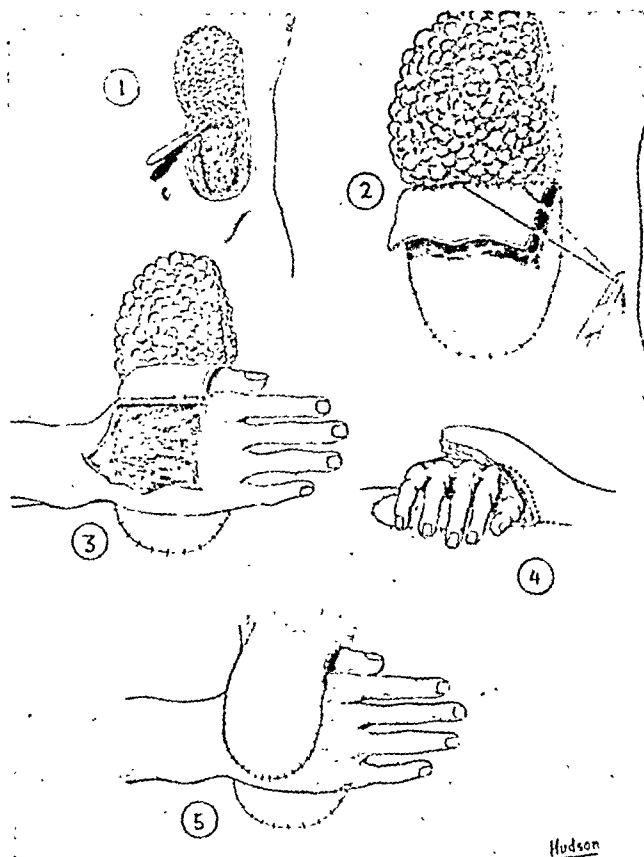


FIG. 1. Illustration of split skin-lined flap graft. 1, A direct flap being raised from the abdominal wall; 2, the graft being continued from the donor abdominal site up the raw pedicle. At the junction of the flap and donor site of the pedicle a continuous suture is placed to keep the split skin in the crevice; 3, shows the split skin graft on the raw surface of the pedicle being sutured to the flap of skin contiguous to the defect on the hand; 4, the hand rests in a completely lined niche, no raw surface being exposed; 5, the flap lines the hand defect. The drawings do not illustrate the pressure dressings placed on the donor site on the abdomen. This is omitted for sake of clarity only.

the early repair. The wound was now a healed, clean wound with all raw surfaces depressed, adhered cicatrix which had covered. The problem was to cover this been healed by scar tissue with little or type of cicatrix with a thick, fatty pad of

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tissue by a closed method, avoiding contamination. Lining a flap graft with split skin offered the desired method.

The advantages claimed and proven were: (1) Lining all raw surfaces of the flap and the donor site provided a closed system with no chance of exposure to infections. (2) A closed wound system allowed for a soft, non-indurated flap on the defect which would permit early tendon, bone or nerve surgery. (3) A closed system prevented serous accumulations, avoiding frequent dressings, and in the case of legs or feet in fixed cast positions, avoided the pooling of serous discharges in positions inaccessible because of the cast.

#### TECHNIC

The donor flap is raised in the same manner as described in an earlier paper by the junior author.<sup>1</sup> The flap is carefully inspected for circulation, and when this is seen to be adequate, a split skin graft, about .025 of an inch is taken from the opposite thigh or chest wall, as the case may be, and laid over the raw donor site. The split skin graft is sutured to this site with a continuous, interlocked black silk suture. The graft is continued from the donor site up the exposed fatty surface of the pedicle of the flap. At the junction of the flap and the donor site, a continuous suture is placed to hold the graft in the crevice. The split skin is sutured to the edges of the pedicle as far as necessary, so that eventually it can be continuous distally with a flap of skin adjacent to the wound on the recipient site, covering all raw surfaces from the defect to the donor site. A pressure dressing of a layer of xeroform gauze and several layers of plain gauze is tied down over the donor site with No. 000 nylon sutures. This pressure dressing goes up to the junction of the flap and donor site. The only pressure on the split skin lining the flap is a careful packing of gauze behind the flap, exerting gentle but moderate pressure. When the skin is sutured to the pedicle,



FIG. 2. This photograph illustrates the under surface of a pedicle to a hand defect. Note how complete the lining is from the hand to the abdomen. No raw surfaces are exposed.

it is drawn snugly from side to side so that good contact is made. It might be said that split skin graft failures on the pedicles are rare.

The defect site is now prepared. All of the cicatrices are removed. A narrow flap of skin, no wider than 1 cm., is laid out in good skin contiguous to the defect and on the side of the defect so as to form a hinge and the beginning of the lining for the raw pedicle. When the hand or foot is brought over to the donor site for suturing of the flap to the defect, this hinge is sutured to the split skin graft coming up the pedicle. The suture used is continuous No. 000 plain catgut. The flap is then sutured to the defect in the usual manner.

#### POSTOPERATIVE CARE

Aside from observation and removal of sutures, there is no special postoperative care. Hand and forearm cases which are not placed in plaster have their grafts easily exposed, and after the eighth day, all the pressure dressings and sutures are removed, and the patient can be free



FIG. 3. A, illustrates a defect on the foot several months old. Patient has multiple fractures of the malleolus with loss of bony substance. He will require a bone graft and stabilization of his malleolus. A good fat pad was needed before orthopedic surgery could be performed. B, twenty-seven days later the patient was taken out of the cast. This is the dorsal view of the flap. C, the under surface of the flap. The entire pedicle is lined as well as the donor site. A few raw spots are present. The closed system called for very few dressings. D, the final flap two weeks after the pedicle was severed. The patient is now ready to have his orthopedic work. He is a clean case.

of dressings if completely healed. There may be a few spots here and there which will require some xeroform dressings for several days more. The feet and leg cases are not disturbed until the pedicle is cut loose, somewhere between the twenty-first to the twenty-fifth day. At that time, it is noticed that the donor site and the pedicle lining are all healed, giving the appearance of a tube. All dressings and sutures are removed at this time and the pedicle is severed. Since the donor site is already covered, it is simple to revise the pedicle at the donor site when it is cut. The recipient site is easily revised since we are dealing with a healed closed area.

#### COMMENT

We have used this technic for wounds of the extremities for over 300 cases. Complications are few. The split skin graft takes in about 95 per cent of the cases. Edge erosion of the graft at the donor site is more frequent than at the pedicle. There is more work in covering the donor site and pedicle at the initial operation, but the final revision operation is shorter. No large flap on the thigh could possibly be lifted without some split skin graft to cover the defect left by raising the flap. It is far simpler to do the surgery of grafting and lining the flap at the first stage, obtaining all of the benefits, than to do a graft to the donor site at the second

stage in an infected site. Skin is the best dressing for any wound.

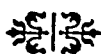
#### SUMMARY

The lining of flap grafts with a split skin graft at the initial operation has marked advantages and is an improvement in technic over the uncovered flaps. The advantages proven are: (1) The closed system prevents infections; (2) it gives

softer non-indurated flaps so that earlier bone, nerve or tendon surgery can be started; (3) it calls for fewer dressings, and (4) used for more than three hundred cases of the extremities, the take of the grafts on the pedicle has been well over 95 per cent.

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PEDICLED skin grafts may be classified as simple, compound, and lined. A simple graft is composed of skin and subcutaneous tissue. A compound graft contains skin, subcutaneous tissue, and bone, cartilage, or muscle. A lined graft is a simple graft, the under surface of which is covered with epithelium by folding the pedicle or by applying an Ollier-Thiersch graft.

From "Operations of General Surgery" by Thomas G. Orr (The W. B. Saunders Company).

# SURGICAL APPROACH TO THE TIBIAL NERVE BELOW THE POPLITEAL FOSSA

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THE preparation of this paper was prompted by the high percentage of tibial nerve lesions below the level of the popliteal fossa which reached this neurosurgical center (McGuire General Hospital) without definitive surgery. It was observed that the surgery for lesions of the tibial nerve in or below the calf either was avoided, or if performed, was inadequate in many instances. The chief reasons for this may be the difficulty in obtaining adequate exposure of that portion of the nerve located beneath the belly of the soleus muscle and the inability to obtain sufficient mobilization of the nerve necessary to bridge large defects. The aim of this paper is directed at overcoming both difficulties, and the methods outlined offer an anatomical approach with minimal injury to the structures of the leg. The procedure has been employed repeatedly without surgical complications and without additional impairment of function attributable to the extensive exposure.

The pathology and lesions of the tibial nerve are similar to those encountered in war injuries of the other peripheral nerves. However, interruption of the tibial nerve below the popliteal region, although usually producing relatively mild motor disability, results in sensory loss to the plantar surface of the foot. It is this anesthetic sole which must be considered as the reason for surgery, regardless of the fact that the patient is apparently not seriously incapacitated. The danger of trophic sores and their resistance to therapy is well known. It is believed that the constant threat to limb and life from potential trophic lesions is sufficient indication for properly performed surgery, regardless of how extensive.

The tibial nerve requires consideration at its various levels. These may be divided into three portions: (1) The nerve in the popliteal space and proximal to the soleus; (2) that portion of the nerve in the lower third of the leg; and (3) the nerve beneath the belly of the soleus muscle.

*This first portion* of the tibial nerve is essentially that situated in the popliteal fossa. From this level arise the motor branches to the gastrocnemius, popliteus, plantaris, soleus and often the origin of the branches to the tibialis posterior and the flexor hallucis longus and the flexor digitorum longus. The tibial component of the sural nerve also begins, as a rule, in the popliteal space.

The skin incision (Fig. 1) is started in the midline of the lower posterior aspect of the thigh and continued down the back of the popliteal space. Curved or transverse incisions aimed at facilitating closure and to minimize subsequent contracting scars of the flexor surface have been suggested and used, but these must be chosen with deliberation and with the knowledge that such incisions may interfere with proper exposure necessary at times to repair the nerve in the depths of the wound between the heads of the gastrocnemius muscles.

The fascia extending between the heads of the gastrocnemius over the popliteal area is incised and the nerve identified in the fat of the lateral portion of the fossa. The nerve is rather superficial proximally, but dips gradually and decidedly as it passes to the distal portion of the space. The medial aspect of the popliteal fossa should be avoided to prevent injury to the popliteal vessels. Palpation for pulsation is not a safe or reliable method of

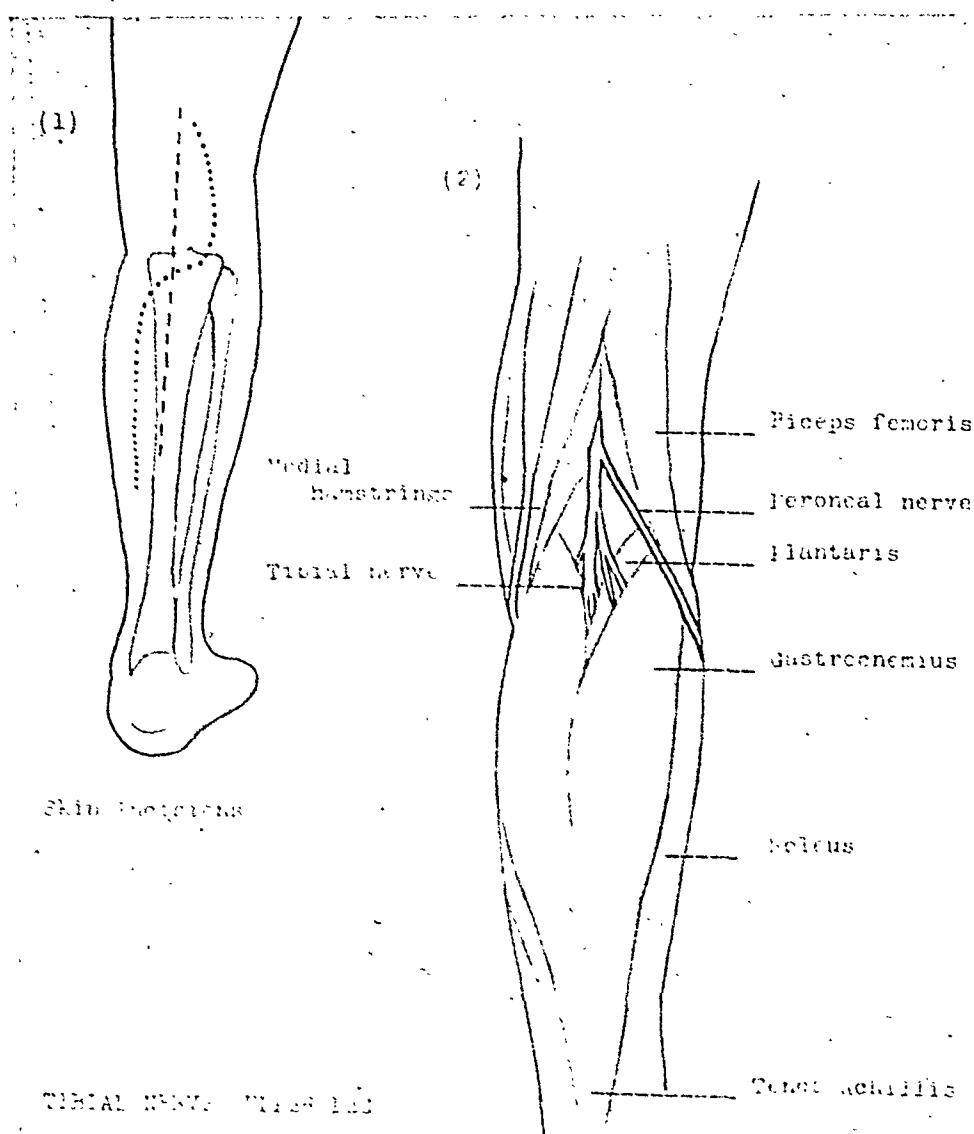


FIG. 1. 1, The skin incisions described in the article are outlined on the posterior aspect of the leg and popliteal area. The usual incision is represented by the straight line, while the approach planned to avoid flexion contractures is indicated by the curved line. 2, The sciatic, peroneal and tibial nerves are shown in relation to the muscles about the popliteal fossa.

recognizing the artery because with the patient in a prone position sufficient pressure by his weight often dampens the pulsation. The common error in locating the tibial nerve is to attempt to find it too deeply and too far medially. If difficulty is encountered, it would be wise to pick up the peroneal nerve, always palpable without trouble, and to trace it back to its junction with the tibial, from which point the latter may be dissected downward.

In splitting the fascia over the gastrocnemius, care must be exercised in order to avoid injuring the sural nerve or its

component. A practical trick is to button hole this fascia and with the finger, the nerve may be located and palpated beneath the fascia which it hugs. Once the nerve is found, the incision may be extended as needed.

The tibial nerve being identified, the loose connective tissue and fat is dissected away. As one proceeds downward, the nerves supplying the two heads of the gastrocnemius arise, one on each side. The other muscular branches progressively are brought into view and are identified by tracing them to the muscles or by electrical stimulation.

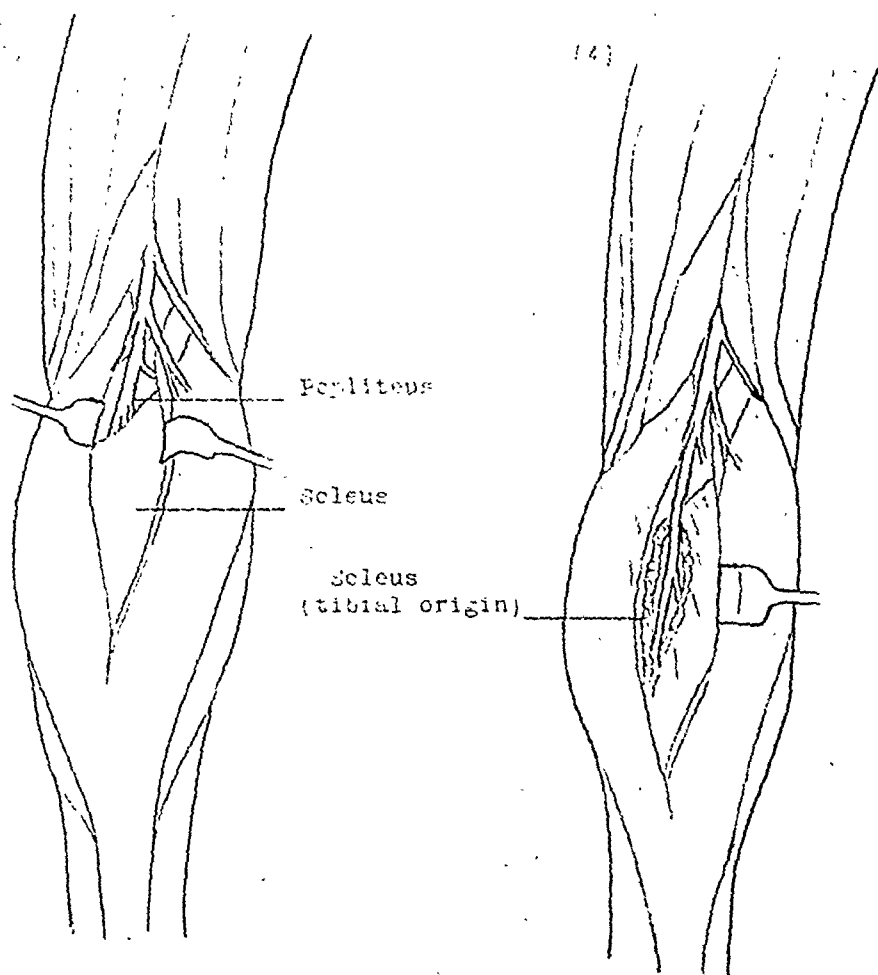


FIG. 2. 3, The heads of the gastrocnemius muscle are separated exposing the posterior surface of the soleus muscle and the tibial nerve entering the hiatus. 4, The hiatus is opened and the soleus muscle is sectioned along its tibial origin as indicated.

The two heads of the gastrocnemius (Fig. 2) may be separated and split down to expose the upper portion of the origin of the soleus muscle on the tibia, interosseous ligament and fibula.

The tibial nerve gives off the main motor branch to the soleus above the plantaris tendon and this branch passes downward over the plantaris and laterally to enter the belly of the soleus. In fact, most of the muscular branches at this level arise and descend lateral to the tibial, therefore simplifying the exposure of the nerve as it begins its course downward to the medial aspect of the leg.

The second portion of the nerve, in the lower one-third of the leg, accompanies the posterior tibial vessels located in the

deep compartment of the posterior group of muscles.

The skin incision is made on the postero-medial aspect of the leg above the ankle. The incision is anterior to the plane of the tendo Achillis.

The tendo Achillis with the accompanying plantaris tendon is retracted laterally exposing the dense smooth intermuscular fascia which divides the posterior leg into two distinct and separate muscular compartments. This fascia is split longitudinally and the nerve which is immediately beneath this membrane may be identified between the tendons of the flexor hallucis longus, laterally and flexor digitorum longus, medially.

Mobilization of this nerve is obtained

without difficulty by blunt dissection with the finger beneath the soleus. In many patients, the soleus muscle has a very low origin from the tibial shaft interfering with proper exposure. This thin origin may be sectioned close to the bone and reflected laterally as needed.

*The third portion* of the nerve is deep in the calf under cover of the soleus muscle. Its visualization usually requires wide exposure and combining the dissections of the first and second levels described above.

The incision is made as for the first portion, but must be carried down on the calf with a gradual curve medially.

An alternate incision is one made in the lateral popliteal area, curved medially and transversely in the popliteal fold, and then downward on the medial posterior surface of the calf.

After the nerve is freed according to the method planned for the first portion the gastrocnemius is split until it becomes tendinous. The muscle is then separated from the underlying soleus, particularly on the medial aspect exposing the entire tibial origin of the muscle. It is also necessary to loosen the tendo Achillis from the structures in the lower leg; its insertion, of course, is left undisturbed.

The nerve above the soleus is lifted by gentle traction, and the hiatus in the soleus through which it passes is enlarged. As the nerve with its branches is retracted laterally, the origin of the muscle is sectioned from the posterior line on the tibia. The soleus may so be cut at its origin for its entire attachment, if necessary, without damaging its innervation or its future function. However, it must be realized that for such an exposure of the soleus, there must be adequate mobilization of the entire gastrocnemius muscle above and tendo Achillis below.

The wound is closed in layers after the soleus muscle has been reattached to the tibia with interrupted mattress stitches. The fascia of the calf is likewise repaired

carefully to prevent cutaneous adhesions to the muscles and also muscular herniations.

Such a wide dissection for the tibial nerve is necessary to expose the nerve, permit proper surgery and to allow sufficient mobilization of the nerve for bridging large defects. Wide exposure is paramount to free the muscular branches which must be carefully teased intraneurally from the main trunk in order to permit downward displacement of the nerve with flexion of the knee. The author has successfully employed the above procedure to repair, without tension, gaps of four and five inches. (Cases I, II and VI.)

In order to avoid the tremendous incision outlined above (Fig. 3), it is possible in selected cases with lesions of the lower tibial nerve to use multiple exposures. If sufficient length for repair is impossible by simple mobilization, the nerve may be exposed in the popliteal space through a separate incision. The branches are freed by intraneural dissection and the nerve is mobilized behind the knee to allow downward displacement with flexion of the knee. The wound is then closed, the leg is flexed and the repair completed in the original exposure. Such a procedure, in addition to allowing repair, shortens closure and permits suturing of the wound behind the knee while the leg is still extended.

In these double exposures, the surgeon must have complete knowledge of the location of all the muscular branches, freeing these gently yet completely, and at no time permitting forcible lengthening of the tibial nerve at the expense of intact motor branches.

Length obtained by extending the ankle joint is dangerous and must be prohibited. This position may lead to an extended foot which resists correction and may require a tenotomy or lengthening of the tendo Achillis. The position of choice, with reference to the ankle, is one of right angles and slight inversion. The length obtained by extending the ankle is too small compared to the risk of permanently crippling the patient.



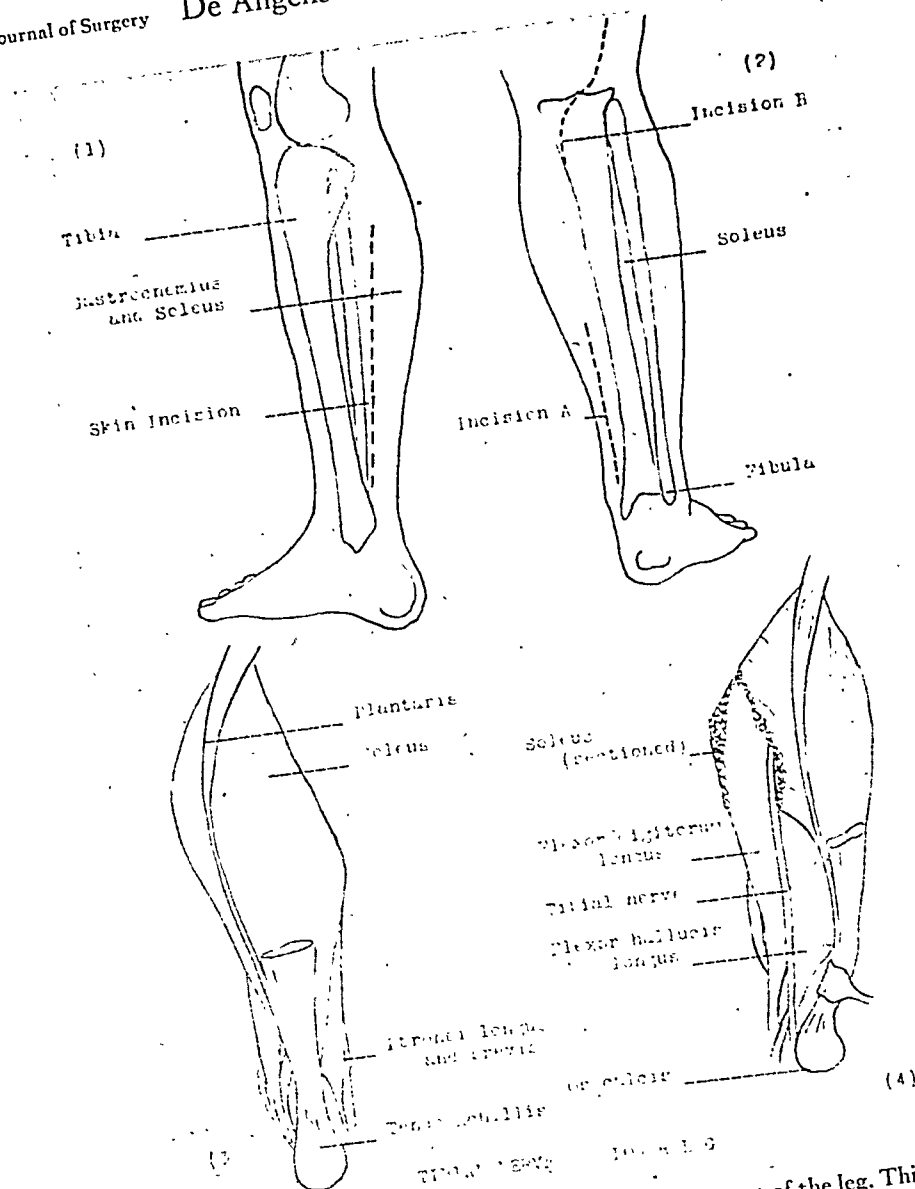


FIG. 3. 1, A single approach is drawn on the medial aspect of the leg. This incision is extended on either end as indicated. 2, Incisions "A and B," indicate the double exposure described to facilitate closure and to avoid one continuous incision. 3, The muscle relationship of the lower leg, posteriorly, is indicated. 4, The tendo Achillis is retracted laterally and the lower portion of the tibial region of the soleus muscle is sectioned at the tibia in order to visualize the tibial nerve.

The plaster cast necessary to maintain immobilization is not disturbed for four to five weeks, at the end of which time the leg is gradually extended by its own weight. No special apparatus or check splints are employed to prevent too rapid straightening. This process usually takes about a week or ten days. While the leg is in the cast, the patient is advised to move his toes and to attempt plantar flexion of the

foot repeatedly in order to maintain tone in the muscles of the calf. The author, although usually employing non-absorbable sutures in routine cases, closes the skin with plain catgut, either continuous or interrupted. This eliminates the removal or the windowing of the cast and also the need for the removal of stitches, which as a rule are quite inaccessible behind the acutely flexed knee.

The following cases in which the patients were operated upon as early as May, 1945, were not submitted for publication until sufficient time had elapsed to observe the results. As yet complete return of function is not present or possible, but it is believed that adequate evidence of recovery is present to indicate continued improvement, and results comparable to those of other nerves. X-rays taken of the operative site when the leg was completely extended revealed intact suture line in each case.

#### CASE REPORTS

**CASE I.** The patient, age twenty-three, a white male, on December 23, 1944, in Germany, sustained a penetrating wound of the right leg, middle third. After the usual débridement and secondary closures, he was evacuated to the Zone of the Interior.

Preoperative examination revealed complete anesthesia of the sole of the foot and in the sural distribution. Gastrocnemius and soleus action was normal, but no function could be elicited in the other muscles supplied by the tibial nerve, either in the leg or foot.

Operation was performed on May 22 1945. The tibial nerve was explored and the nerve was found completely interrupted in the middle one-third of the calf, necessitating resection of the entire tibial head of the soleus muscle. A  $12\frac{1}{2}$  cm. gap resulted from the resection of the scarred ends. Anastomosis was performed with fine tantalum sutures. This patient's leg was kept in flexion for five weeks.

Postoperatively, although complete recovery is not expected for some time, sufficient evidence is present to indicate continued improvement. On January 26, 1946, Tinel's sign was in the ball of the foot, having progressed the expected rate down the course of the nerve. The patient could flex the third, fourth and fifth toes, and there are areas of hypesthesia on the lateral aspect of the sole, particularly near the ball of the foot. Additional return of sensation is expected. On February 25, 1946, the sole of the foot in front of the heel had become paresthetic.

**CASE II.** The patient, age twenty-two, a white male, sustained a penetrating wound of both thighs and legs on December 12, 1944, in Germany, with a compound fracture of the right tibia, middle third. This patient was

transferred to the Zone of the Interior after the preliminary train of evacuation.

Preoperative examination revealed complete anesthesia in the sole of the foot and sural distribution. Gastrocnemius, soleus and posterior tibial functions were grossly normal. No function was noted in the remaining muscles innervated by the tibial nerve in the leg and foot.

This patient was operated upon May 24, 1945, and after section of the tibial head of the soleus, the completely severed nerve was found in the callous of the fracture. Resection of the ends resulted in a gap of 10 cm. The nerve was repaired with fine tantalum wire. This patient's leg was kept in flexion for five weeks.

This patient, likewise, has not been observed sufficiently to evaluate the final results, but on January 23, 1946, there was a patchy return of sensation in the sole of the foot with flexion of the toes. Tinel's sign is in the sole of the foot medially, and in view of the partial sensory recovery and the progressive Tinel from the mid-leg, the prognosis in this case is good. On February 25, 1946, there was hypesthesia of the entire arch of the foot with almost normal sensation of the sural distribution. The heel has become paresthetic.

**CASE III.** This soldier, age twenty-seven, sustained a penetrating wound of the right leg, lower one-third, with fracture of the fibula in February, 1945. On April 11, 1945, a neurorrhaphy was attempted through a small incision, overseas.

Preoperative examination revealed anesthesia of the sole of the foot with function of the soleus and gastrocnemius muscles. No function was present in the other muscles supplied by the tibial in the leg and foot. Tinel's sign seemed to be fixed at the site of injury.

On September 13, 1945, the patient was operated. In addition to the exploratory incision, a second incision was made behind the knee in order to mobilize the nerve and its branches, after method described above, and a gap of 4 cm. was overcome and repaired with fine tantalum wire. This patient was kept in plaster cast for five weeks.

On February 13, 1946, the anesthesia of the sole of the foot for the most part was replaced by hypesthesia with the exception of the region of the great toe and the first metatarsal head. There was some plantar flexion of the toes.

**CASE IV.** This patient, a white male, age twenty-five, sustained a perforating wound,

middle one-third left leg with fracture of fibula, on February 3, 1945.

Preoperative examination revealed complete sensory loss in the sole of foot and hypesthesia in the sural distribution. There was no function in the gastrocnemius, soleus and tibialis posterior. No other muscles supplied by the tibial showed evidence of function.

On October 19, 1945, through a wide exploration described above with resection of the soleus, the tibial nerve was explored. Excessive bleeding associated with marked vascularity of the area was encountered and it was believed that extensive mobilization of the nerve might produce interference with the vascular supply of the leg. Hence, a bulbar anastomosis was performed and the wound was closed. The patient was placed in a cast with the knee in flexion for about three weeks, after which his leg was allowed to extend. On November 21, 1945, the wound was re-opened and a 8 cm. gap resulted after excision of scarred nerve, which was repaired with tantalum wire and the patient was again immobilized for five weeks.

On February 24, 1946, Tinel's sign was 19 cm. below the area of repair.

CASE V. On January 2, 1945, in Belgium, this patient, a white male, age twenty-two sustained a perforating wound in the right leg above the ankle with a compound fracture of tibia and fibula. On August 15, 1945, a skin graft was applied to the unhealed sores of the leg.

Pre-operative examination revealed partial ankylosis of ankle, anesthesia in the entire sole of the foot with paralysis of the intrinsic muscles of the foot.

On December 6, 1945, the leg was operated upon after the method described above, with a secondary incision behind the knee to mobilize the nerve and its branches and a 9 cm. gap was closed with fine tantalum wire.

On February 20, 1946, Tinel's sign was 8 cm. distal to the wound. There was patchy return of sensation in the region of the ball of the foot, with deep sensation of the entire sole.

CASE VI. On December 6, 1944, in Germany, this patient, a white male, nineteen years of age, sustained a penetrating wound of the right lower leg, with fracture of tibia. A draining wound and sinus persisted at the time of surgery. In view of the persistence of sore in the area of injury, this patient had been placed on prophylactic series of penicillin pre- and postoperatively.

On December 5, 1945, through a wide incision the medial aspect of the lower leg was explored. A secondary incision was made in the popliteal region and 12 cm. of nerve gap was bridged by the procedure. A fine tantalum wire anastomosis was carried out. This patient was kept in a cast for about five weeks. Although the wound had been closed completely at the time of surgery, removal of the cast revealed the presence of a large sore at the lower end of the incision in the leg. This was treated conservatively for several weeks and finally covered with a split skin graft on January 23, 1946.

On February 25, 1946, the grafted area had healed completely and a Tinel's sign elicited in the instep. There was hypesthesia of the plantar aspect of the toes which was absent prior to surgery. This may or may not be the result of sensory overlay.

CASE VII. On November 8, 1944, a white male, age twenty-two, sustained a perforating wound of the lower one-third of the left leg. Preoperative examination revealed complete sensory loss in the sole of the foot with paralysis of the intrinsic muscles of the foot.

After a stormy convalescence, the patient's infected wounds healed and on April 25, 1945, through a medial incision, the tibial nerve was explored and repaired. At that time a 3-inch gap existed and the repair was done under considerable tension. A very poor prognosis was given because of the undue tautness of the anastomosis and because the scarred nerve ends had not been completely excised. As was expected, the patient showed no evidence of improvement, and on November 16, 1945, medial exploration with a secondary relaxing incision behind the knee was performed. The secondary excision of the neuroma resulted in a gap of 4 cm. The patient was kept in flexion for about five weeks.

On February 25, 1946, Tinel's sign had descended 5 cm. distal to the repair. No evidence of sensory return was seen.

CASE VIII. (Hospital Register No. MCGH 6003), age 27, male, white.

On June 18, 1944, in France, this patient, a white male, age twenty-seven, sustained a penetrating wound in the lower one-third of the right leg with compound fracture of the right tibia. On January 23, 1945, and again on May 4, 1945, painful cicatrices were excised from the region of the injury.

Preoperative examination revealed that patient had complete sensory loss in the sole of

the foot. There was no motor paralysis other than that of the intrinsic muscles.

On August 27, 1945, the medial aspect of the leg was explored and the nerve found completely interrupted. Excision of the neuroma produced a gap of  $6\frac{1}{2}$  cm. which necessitated a secondary incision behind the knee for mobilization of the nerve and its branches. Repair was completed with fine tantalum wire and the knee was kept in flexion for five weeks.

On January 30, 1946, Tinel's sign had progressed to the arch of the foot. No definite sensory changes were noted at that time.

CASE IX. On October 22, 1944, in France, the patient, a white male, twenty years of age, sustained a perforating wound of the lower one-third of the left leg. On October 23, 1944, ligation of posterior tibial was done overseas.

Preoperative examination revealed function in the gastrocnemius, soleus and tibialis posterior, but no other function in the remaining muscles supplied by the tibial nerve. There was sensory loss in the entire sole of the foot.

On September 6, 1945, the nerve was explored as described above with complete sectioning of the tibial origin of the soleus. A gap of  $9\frac{1}{2}$  cm. resulted in the excision of the scarred nerve ends. Repair was accomplished in the usual fashion and the patient was kept in flexion for about five weeks.

On February 6, 1946, there was a patch of hypesthesia replacing the anesthesia extending from the arch across the ball of the foot, including the second, third and fourth toes. The remainder of the sole was paresthetic when tapped, indicating probable early return of sensation. Motor function was unaltered.

CASE X. On February 12, 1945, in Germany, this patient, a twenty-five year old white male sustained a perforating wound of the lower one-third of the right leg.

Preoperative examination revealed anesthesia of the sole of the foot and heel. There was weakness in the flexor of the toes. Remainder of the muscles were apparently normal.

On November 9, 1945, through a medial incision, the tibial nerve was explored. Secondary relaxing incision was performed and a 4 cm. gap was repaired with fine tantalum wire.

On February 9, 1946, there was replacement in patches of the anesthesia by hypesthesia, so that the entire ball of the foot and instep was partially sensitive. Lateral aspect of the foot and heel was still anesthetic and gentle tapping produced paresthesia in this area. Tinel's

sign was diffuse in the sole of the foot. No motor changes were noted.

CASE XI. A white male, age twenty-eight, sustained perforating wound with fracture of astragalus, calcaneus and medial malleolus on December 30, 1944, in Belgium. On January 3, 1945, a screw was placed to hold the malleolar fracture.

Preoperative examination revealed anesthesia of the sole of the foot and paralysis of the intrinsic muscles of the foot.

On September 26, 1945, neurorrhaphy was performed through an exposure described under *second portion*. No secondary incision was necessary in this case as enough mobilization was obtained to overcome a gap of 2 cm.

On February 1, 1946, there was replacement by hypesthesia of the anesthesia in the instep and part of the heel with a small area of sensory return noted in the ball of the foot behind the second and third toes. Tinel's sign had descended 17 cm. since operation.

CASE XII. On January 1, 1944, this patient, a white male, age twenty, sustained a self-inflicted accidental gunshot wound, perforating the left ankle. On July 25, 1945, a sub-astragalar arthodesis was performed. On May 8, 1945, a neurolysis of the tibial nerve was attempted, but no return in function was noted. Paralysis of the intrinsic muscles of the foot existed with complete sensory loss in the sole of the foot with the exception of a portion of the heel.

On November 7, 1945, the nerve was explored and 5 cm. of scarred nerve was excised. A secondary mobilization incision was necessary behind the knee. Repair was performed in the usual fashion and the knee was placed in a plaster cast for five weeks.

On February 16, 1946, examination revealed a decreasing area of anesthesia in the sole of the foot, laterally and anteriorly. Tinel's sign was present in the instep.

#### SUMMARY

1. The anatomy and surgical approach of the tibial nerve below the popliteal fossa is discussed.

2. Twelve cases, with preliminary follow-up, are reported in which neurorrhaphy of this portion of the tibial nerve had been performed. Nerve defects of as much as five inches have been repaired by the outlined procedure.

# CONTINUOUS, VERTICAL MATTRESS SUTURE

## ITS APPLICATION AND USEFULNESS

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IN order to justify the introduction of another method of suturing the skin edges of an operative wound, several

ence to the interrupted on-end vertical mattress suture was made in a paper by R. W. Longyear in 1890. A continuous,

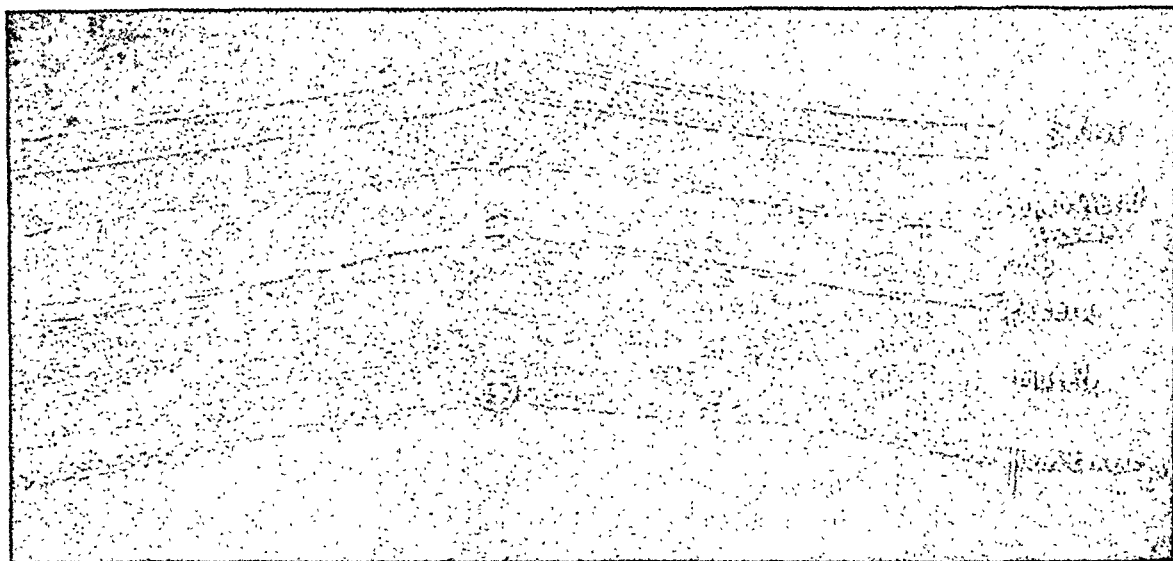


FIG. 1. Cross section of single loop of suture.



FIG. 2. Suture as seen from above the suture frame.

prerequisites are necessary. A review of the surgical literature should be made to determine whether such a method of suturing has been used previously. A critical enumeration of other methods of skin suturing, and a comparative study of previous methods with the newer method should be done. The introduction of a new suture is justifiable, if some of the defects of previous methods can be overcome.

A review of the surgical literature on skin suturing indicates that the first refer-

ence to the interrupted on-end vertical mattress suture was made in a paper by R. W. Longyear in 1890. A continuous, on-end, vertical mattress stitch was described independently in 1918 by two authors; Arthur Edmonds in the *Lancet*, under the heading "New Inventions" and F. Roberts in this country. The latter author states, "so far as I have been able to learn no description of a stitch I am using at the Indianapolis City Hospital for closing skin wounds has yet been published." Both of these references contained an incomplete description of this stitch. A search of the more recent literature shows

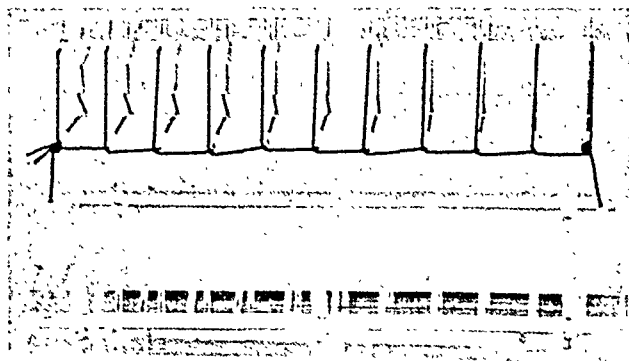


FIG. 3.

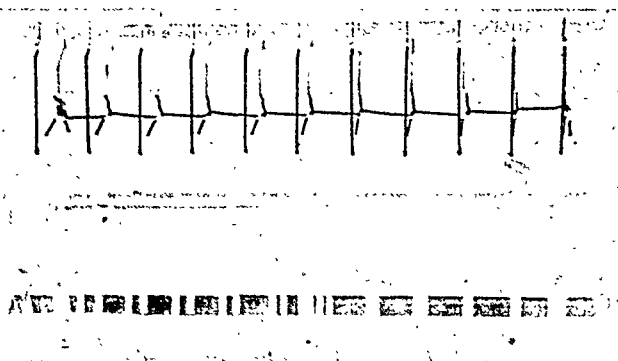


FIG. 4.

FIG. 3 and 4. Two photographs showing suture in side view.

no further discussion of this method of skin closure.

The ideal type of skin suture is one which will ensure apposition of the skin edges without tension. If an operative incision divides the skin in a plane at right angles to its surface, closure of the wound should attempt to restore the continuity by approximating the full thickness of the incised skin edges. The suture which fulfils this purpose should maintain the approximation until the normal healing process has united the skin edges firmly. When union of the skin edges is sufficient to preserve approximation, the skin suture is no longer necessary and should be removed.

A skin suture should not bind the wound edges together tightly and interfere with the blood supply necessary for normal healing. Rather should the suture be placed loosely to compensate for the edema which follows operative trauma. The knots which anchor the ends of a continuous suture, the points where a continuous suture turns upon itself in making a chain-stitch, and the knots of an interrupted suture should be as remote as possible from the skin edges, for these tend to produce distortion when placed in close proximity to the incision.

Although the time required to place any type of skin suture is comparatively short, nevertheless part of the time required in an operation is used for this purpose. It would, therefore, be appropriate and helpful to use that type of suture which best fulfils its purpose and can be inserted with

facility. It is generally accepted that a continuous suture can be placed more rapidly than an interrupted suture, and the advantages of a continuous suture were recognized as early as 1891.

A skin suture maintains apposition of

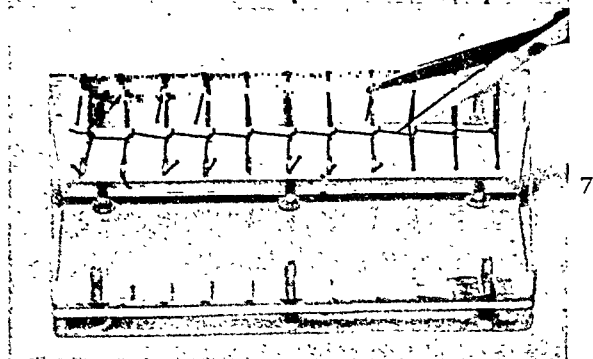
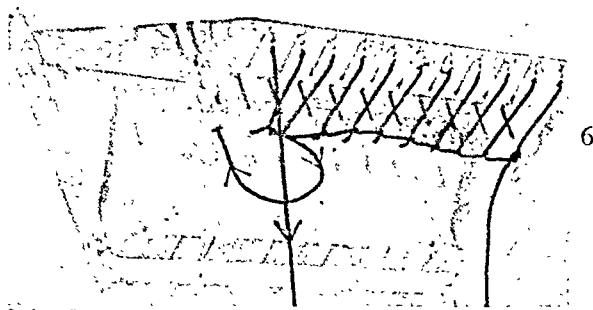
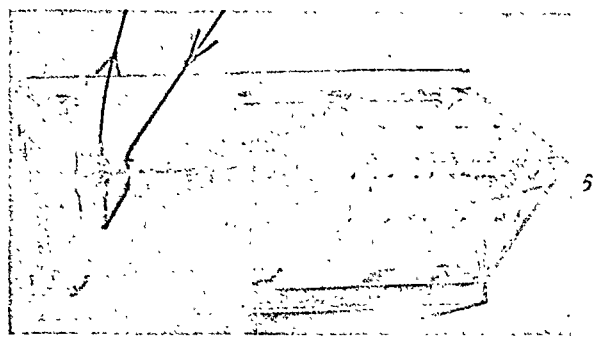
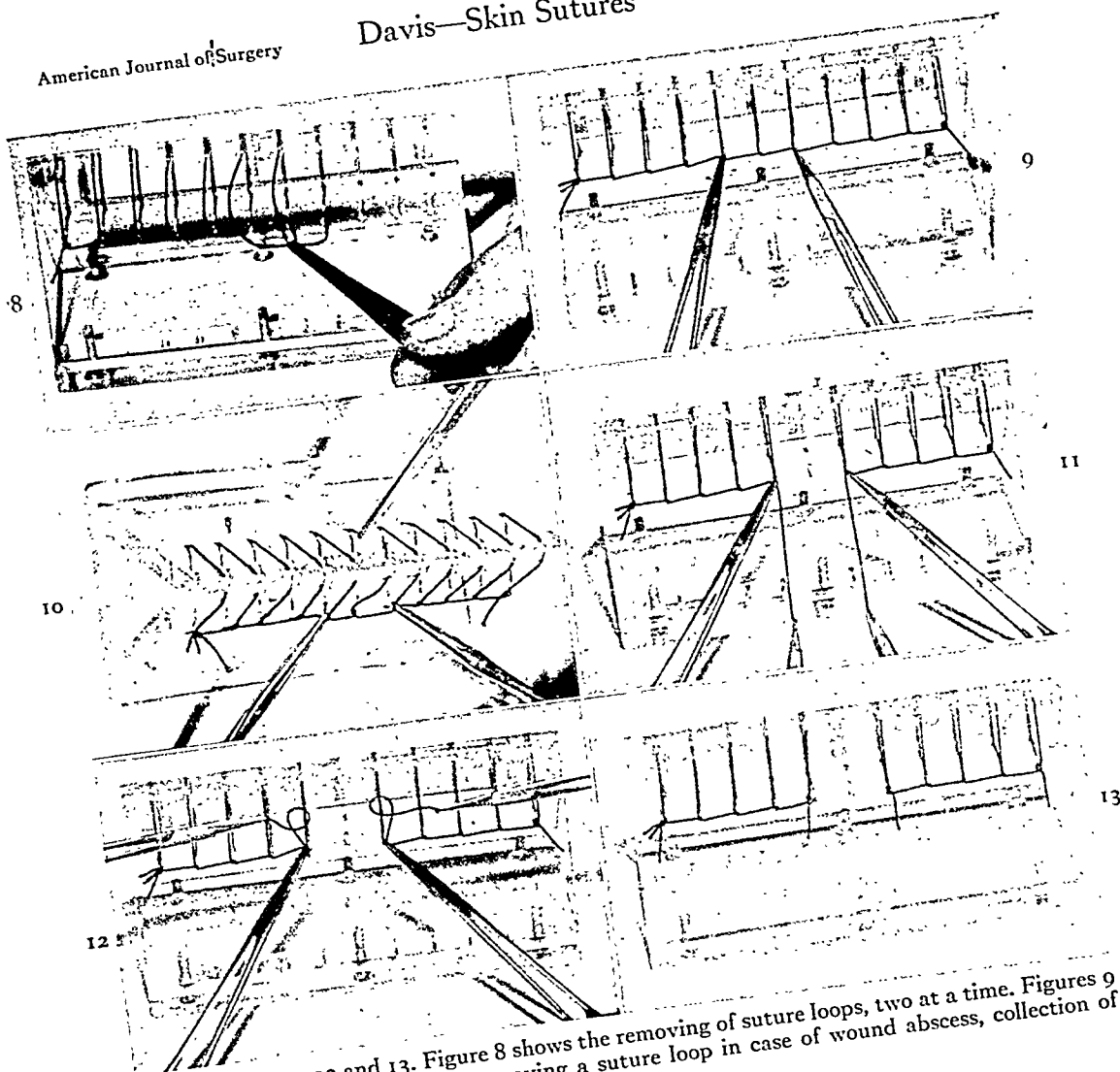


FIG. 5. Making the first loop of the suture; the arrows show the path of the needle.

FIG. 6. Making the last loop of the suture; note direction of arrows.

FIG. 7. Cutting suture loops for removal.



FIGS. 8, 9, 10, 11, 12 and 13. Figure 8 shows the removing of suture loops, two at a time. Figures 9 to 13 illustrate the technic of removing a suture loop in case of wound abscess, collection of serum, etc.

the skin edges by tension which is greater in the plane of the suture than that which prevails between the sutures. It follows, therefore, that the blood supply in the plane of the suture is less than that between the sutures. If an interrupted suture maintains adequate approximation in the plane of the suture, the skin between the sutures must be inadequately approximated. Although this method of reasoning indicates a defect which is common to both interrupted and continuous sutures, the tension in the loops of a continuous suture may be more evenly distributed by manipulation after the suture has been placed. It is evident, therefore, that uniformity of approximation is more difficult to obtain with an interrupted suture.

The most prevalent objection to a continuous suture is its inadequacy in the event of wound infection, and under such circumstances it is more difficult to drain a wound abscess than when an interrupted suture is used. However, this difficulty may be overcome by the removal of a segment of the continuous suture as described in this paper.

The day on which sutures are to be removed is often a source of unpleasant memory to many patients. Sutures which are tied tightly and have cut through the skin cause considerable pain and tenderness and often, "sterile pus" is present. Under such circumstances it is difficult to find and remove the suture. Some surgical texts recommend general anesthesia for

the removal of sutures in uncontrollable children. A skin suture which is easily removed should therefore be helpful to the surgeon and the patient.

#### MECHANICAL FACTORS

The suture is begun at the end of the incision farthest from the operating surgeon.

A straight skin needle passes through the everted skin edge at an angle as illustrated in Figures 1 and 5. It emerges on the side nearer the surgeon.

The skin is elevated by traction on the two ends of the untied suture and the deeper half of the suture loop is completed. The knot is tied as far as possible from the skin edges.

The remaining sutures are placed in the same manner and a chainstitch is formed as illustrated in Figures 2, 3 and 4.

The last suture is completed by reversing the motions used in making the first stitch. (Fig. 6.)

The simplest method of tying the end knot to complete the suture is as follows: the horizontal connecting loop between the last two sutures is pulled out and a square knot is made by tying the loop and the end of the suture together. (Fig. 6.)

To remove the suture, each loop is cut with sharp scissors. (Fig. 7.) The loops may be removed two at a time by grasping the points where the suture turns upon itself. (Fig. 8.)

When a wound abscess, or a collection of serum is present, a segment may be removed and the suture retied, as illustrated in Figures 9 to 13 inclusive.

The suture which is presented by this paper has the following characteristics:

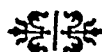
(1) It is a continuous suture, which is easily and rapidly placed. (2) It is removed by cutting the suture at points which are distinctly visible and readily available. (3) After cutting the suture, the elasticity of the skin loosens the segments, and its removal causes minimal discomfort. (4) The time required for its removal is approximately half that required for removal of an interrupted suture having the same number of segments. (5) All knots and points where the suture turns upon itself are remote from the skin edges. (6) When wound infection is present, a segment of the suture may be removed and the opened suture may be retied easily and securely. (7) The skin edges are not distorted by the suture. (8) The tension of the suture is evenly distributed among its segments.

This suture is suitable for the closure of abdominal wounds, and has been devised for that purpose. A transparent plastic model was designed and used to demonstrate the mechanical factors involved.

The author wishes to thank Dr. Gregory L. Robillard of Brooklyn, N. Y., for many valuable suggestions; and Mr. David Lewis of New York, N. Y. for his help in the construction of the model used to demonstrate this suture.

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# EXPERIENCES WITH PULSATING HEMATOMA

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IN a publication in 1943, I have discussed the problem of pulsating hematoma from an academic viewpoint. Moreover, this article was based on experiences derived largely from civilian practice. Since this time, having had the opportunity of seeing a fairly large number of arterial wounds, I find that revision of the previously expressed opinions is indicated.

It is evident to anyone seeing a large number of war casualties, that pulsating hematoma (sometimes called false aneurysm), is a rather common lesion. This is especially true if one is on the alert for its appearance. Reports from military surgeons that they see only rare cases, often emanate from those who occupy a stage in the evacuation chain, so that their patients after a time are transferred to another installation; there the condition is discovered and the patient subjected to operative intervention. Not infrequently one is completely overlooked. One of our patients, with multiple wounds was treated for a fractured femur by balanced traction for seven weeks. At this time a spica cast was applied. On the following day he suffered a severe hemorrhage from a pulsating hematoma of the posterior tibial artery on the same leg. At this point he had a seemingly insignificant 1 cm. shell fragment penetrating wound.

In my experience one pulsating hematoma is present in approximately every 500 surgical admissions of wounded and sick from an active war theater. At first there appeared to be an equal incidence between arteriovenous fistulas and pulsating hematoma in accordance with Makin's observations in World War I. This, however, changed, so that we have seen about five hematomas to three fistulas. A rather

large percentage of the arteriovenous communications are associated with a false aneurysmal sac, so that they might be considered in the same category as the hematomas.

The term "pulsating hematoma" has validated itself, for they actually do palpably pulsate in many instances.

The lower extremity apparently is more frequently involved than the upper. The posterior tibial artery and the femoral artery have been most frequently the site of the rupture. The popliteal, brachial, subclavian, radial and ulnar arteries are next in frequency. Even the small vessels have not been immune, for in one patient we have found an ulnar arterial hematoma in the hand at the level of the deep palmar arch.

*Pathology.* Three types of arterial injuries are observed: (1) Complete transection of the artery; (2) incomplete laceration of the artery without injury of the accompanying vein and (3) incomplete laceration of the artery and laceration of the accompanying vein. In the first instance, bleeding will depend upon the state of the surrounding tissues. If there is a wide laceration of the soft tissues, the patient will probably bleed to death. However, certain forces attempt to prevent exsanguination; the artery retracts, the intima curls up and partially obstructs the lumen; the injured vessel goes into spasm; as the hemorrhage proceeds the systemic blood pressure falls, and with the shock reaction all of the blood vessels of the extremities go into spasm. Should the soft tissue laceration be a comparatively small one, or so situated to tamponade the hemorrhage, clotting will take place and the factors mentioned will successfully conclude the hemorrhage. Clotting will then also take place in the

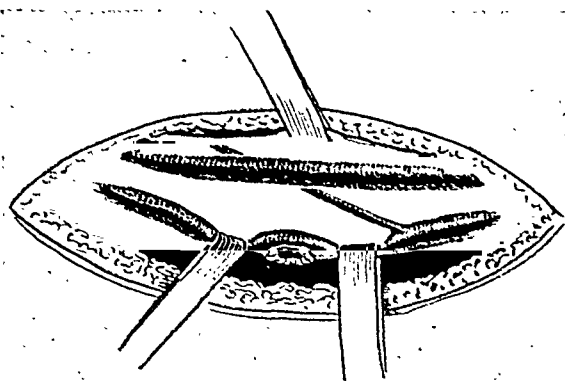


FIG. 1. Depicting the artery, vein and nerve. The artery is suspended upon two tapes, one above and one below the rent. The nerve is also suspended on a tape so that it may be held free from the dissection.

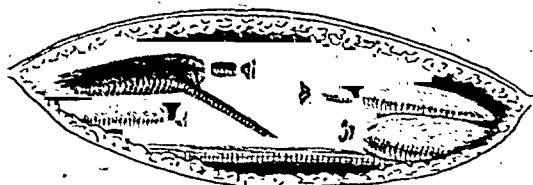


FIG. 2. Both the artery and the vein have been tied, the artery with double ligatures, and both have been transected. The vein is tied when it contains a clot. Note that the arterial ligature is just beneath a branch. This is the ideal site of arterial ligature.

lacerated vessel, and a spontaneous cure will have taken place.

If the second possibility has taken place (partial arterial rupture without injury to the accompanying vein), an entirely different sequence of events takes place. Retraction of the artery only widens the rent, so that the hemorrhage will be brisk. When the systemic blood pressure falls, the retractive narrowing and spasm of the vessel caliber may slow or stop the bleeding. The surrounding tissues, usually large muscle groups, are then pressed into the arterial rent and seal it off. The muscles are pressed into the wound both by their natural spasm as the result of the injury and by the dressings applied by the aid of man or surgeon. This condition may obtain for varying lengths of time, often a week or more, or, in one case that we have seen, ten weeks. Clotting does not take place, for some blood apparently oozes past the obturated rent, and along the natural course. There may even be an attempt of intimal proliferation upon the muscle plug.

When the muscles, however, are brought into action, they move in such a way to dislodge the plug over the arterial defect and hemorrhage takes place. The amount of the hemorrhage is dependent upon the surrounding tissues. These are pushed away until the pressure within the hematoma is equal to the blood pressure. If there is a

vent to the cavity, in the form of an external wound which is yet unhealed, there will be an external hemorrhage, which may be exsanguinating. Usually the vent is small, or the wounds through the different layers do not correspond and the hematoma cavity spreads in all directions pushing the surrounding tissues away. In this manner it may involve the entire calf of the leg, forearm, etc. At the edges of the hematoma, there is usually some clotting. This is especially true where the different muscle layers have been separated, so that the irregular prolongations are reduced and a smooth rounded cavity results.

Sencert describes this "like a river in flood which, after spreading far and wide, gradually withdraws and at a given moment settles down into its permanent bed." The surrounding tissues become infiltrated with serum and leukocytes and form a more or less firm wall for the hematoma, which some have likened to a true aneurysmal sac. This sac may even be lined with an intima-like structure, but none of the other coats of the arterial wall are observed. Often it is laminated with an onion-peel character.

The position of the artery with respect to this coat is in apposition with the wall. In none of the cases seen following war wounds, have I observed the artery traversing the center of the cavity, as I have occasionally seen in civilian cases.

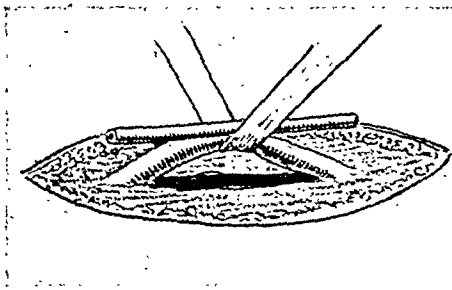


FIG. 3. The method of provisional ligation. A tape is passed beneath the artery and a piece of soft rubber tubing placed upon it.

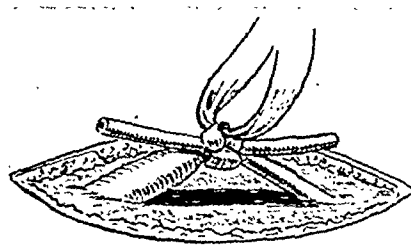


FIG. 4. The completed provisional ligation. The moistened tape is tied over the rubber tubing. To release, either a scissors may be introduced into the tubing, or the tape cut upon the tube with the scalpel.

The third possibility is that the accompanying vein is injured with the artery, neither being completely transected. Should the two wounds exactly coincide, it is possible that the contracting surrounding musculature will press them together and they will mutually plug each other. The pressure of any extravasation is markedly reduced by the fact that the blood readily finds its way into the receiving vein so that a pressure vent is automatically obtained. On the other hand the arterial and venous contractility are far different so that direct apposition (and the production of an arteriovenous fistula) is comparatively rarely attained. Therefore, there will be a certain amount of extravasation. The extravasated blood finds the central end of the open vein easy of access and is readily taken up. Therefore, the pressure in the hematoma cavity is low and the pseudo-sac will be small. The edges of the tract are soon lined by an intimal proliferation so that in this instance there will be an arteriovenous fistula with a false aneurysmal sac. I use this term in contradistinction to pulsating hematoma, as the pressure differences change their therapeutic approach.

**Symptoms.** The symptoms of pulsating hematoma depend upon the location of the mass and the associated injuries. Usually there is a history of rather severe bleeding at the time of the injury. In one case a foreign body, in the form of a large dressing was found in the wound some

twenty days after wounding, suggesting that there was severe hemorrhage at the time of the original débridement. The further history may be very undramatic until a more or less severe hemorrhage takes place one to three weeks or more after the original injury. Pain may or may not be a prominent feature but usually is. In one instance a psychiatric consultation was called because no apparent reason for pain was observed in a patient who would not use his walking cast. Pain frequently radiated down the course of a nerve and in some a progressive paralysis was noted.

Most commonly the most pronounced symptom is a delayed hemorrhage, which calls attention to a large brawny mass. This may or may not be fluctuant and the overlying skin may be red and shiny giving the appearance of an abscess. In two of our recent cases, an alert medical officer discovered a hematoma in what appeared to be an obvious abscess. Peripheral ischemia may be present. One of our patients had been taking Buerger's exercises for three weeks for a supposed frost bite, when an abscess was noted in the calf of the leg. He was referred to the surgical service for care for the abscess when the pulsating hematoma was discovered.

The most typical sign is the systolic bruit. This is nearly always audible, although its exact location must, in some instances be carefully sought. Usually it is easily heard over the point of maximum swelling. If not, auscultation should be

carried out proximal to the mass and in all parts of the extremity. Only the bell type of stethoscope should be used. A quiet room is an essential. It is not possible to hear a faint bruit with a radio blaring in the ward.

In the previous article I said that palpable and visible pulsation was rare. This is wrong. In many of the cases the pulsation is easily visible and is of the expansible type.

*Diagnosis.* Unfortunately, the diagnosis is usually made only after a hemorrhage or a large brawny swelling has appeared. Were this not the case a hemorrhage might often be spared and the extensive swelling avoided if surgeons would auscultate every wound which has bled profusely at the time of injury. Certainly every patient with an abscess which appears following any injury should be carefully examined for the possibility of a pulsating hematoma before the inadvertent incision has embarrassed the surgeon.

The differential diagnosis between a pulsating hematoma and an arteriovenous fistula with or without a false aneurysm may be quite difficult. In the simple fistulas, there will be no appreciable mass. In the false aneurysm type, however, there may be a considerable mass, and the exact evaluation may be most difficult. When an arteriovenous communication exists there is frequently a thrill as well as a bruit. This is rare in the hematomas. The bruit of the arteriovenous fistula is machine-like and of a to-and-fro variety, while in the hematomas it is systolic in timing. Perhaps of greatest value is the Branham phenomenon. In the arteriovenous connections, there will be a marked slowing of the pulse rate with compression of the artery proximal to the lesion. An x-ray film of the heart will also show a marked reduction of the size of the cardiac shadow when the vessel proximal to the fistula is compressed. Major Alfred O. Miller and I have also observed a marked change in the roentgenkymogram, which has helped us in the

differential diagnosis in at least one patient.

*Treatment.* Arterial suture at the time of the injury would completely avert the appearance of pulsating hematomas. This will probably never be the case, for in the face of even the most modern evacuation policy, certain of the arterial wounds will be plugged at the time the wound is debrided. It was originally my feeling that adequate first aid in the form of good compression would seal off the artery. This was wrong. The only first aid that will prevent the appearance of pulsating hematoma is a direct operative repair of the injured vessel, or its ligation. Some surgeons, during operation for nerve repair have noted arteries that were notched and yet intact, suggesting that they had sealed off and had healed with an ultimate narrowing of the artery. On the other hand, far more frequently we have observed patients who have had ideal first aid, with excellent compression and complete immobilization for associated fractures, give their first expression of a pulsating hematoma in a severe hemorrhage several weeks after wounding.

We have found little leeway in choosing the time for the operative intervention once the pulsating hematoma has been discovered. Only in one instance did we avoid operation. This was a patient who had a hematoma of the brachial artery caused by a small shell fragment. He had a severe hemorrhage ten days after wounding. A compression bandage was applied. Because of an associated jaundice the operative intervention was delayed. After about ten days more the pain in his arm became somewhat relieved and the bruit disappeared. Gradually there was absorption of the clot. Six weeks after the original injury, there was again a small hemorrhage as evidenced by an increase in the size of the tumefaction and reappearance of the bruit. He was watched for another six weeks at which time the mass had become markedly reduced in size and no bruit was

audible. He was evacuated to the zone of interior, and so far we have lost track of him. He may have had a spontaneous recovery. All of the other cases have required operative intervention without much delay, so that we now believe that operation should be carried out as soon as the patient's general condition warrants. This is unfortunate as delay would certainly enhance the collateral circulation.

In arteriovenous communications, on the other hand, delay in operative intervention is not as hazardous. Because of the low pressure sac, one does not fear secondary hemorrhage. It is beyond the scope of this report to delineate the indications for early operation in arteriovenous lesions. Suffice it to say that fear of hemorrhage is not one of them.

The positioning of the patient on the operating table is often quite complicated because of the frequently associated fractures and their many appliances. It is wise to have the orthopedic surgeon arrange the position on the table so that the least damage will result to the fracture. Nevertheless the demands of exposure must be of primary importance. Hemorrhage may be severe so that all preparations for blood transfusion should be made with at least 1000 cc. of blood available immediately. Usually we see that a venoclysis is started before beginning the operation so that there will be no delay or difficulty in starting this.

The use of a tourniquet is a great help if it is possible to use it properly. I prefer the use of a blood pressure cuff, as this can be applied or released as the occasion demands. If one is dealing with a vessel at the root of the limb, it may be impossible to use a blood pressure cuff. In such cases an ordinary tourniquet is applied but a sterile tourniquet is also prepared so that if the first is released the surgeon is prepared to apply another in the sterile field. Many patients will be brought to the operating theater with a tourniquet or compression bandage in place. This should be adjusted to the proper position before draping is

started so that no change will be necessary when the operation has begun.

The proper draping of the extremity is important aiming toward a maximum of exposure and maneuverability. We have found that the simplest method is circumferential preparation as though an amputation were to be done. This permits manipulation of the extremity, as well as the application of a sterile tourniquet.

Preliminary provisional ligation of the tributary artery is of some benefit when the application of a tourniquet is difficult or impossible, as in the root of the limb. It should not be expected, however, that this will afford adequate or even very marked hemostasis. At the root of the limb, especially in the thigh, the collateral circulation is so rich that a provisional ligature of the femoral or iliac artery seems to have but little effect in stanching the flow of blood. It does help however and should be performed. Lt. Colonel Arthur Touroff has even suggested a transthoracic provisional ligature of the subclavian artery. For such a ligature I prefer to use a wet tape (such as that commonly employed to elevate the cord in a herniorrhaphy). This is passed beneath the artery and tied over a small length of soft rubber tubing. The use of the rubber tubing is advantageous; when the tape is to be removed one can slide a scissors into the tube and simply cut the tape. It also compresses the artery without traumatizing it.

The approach to the hematoma should be by the classical exposure of the injured artery. I have on several occasions mistakenly used the wound of entrance or exit as a guide. This temptation should be avoided as the proven incisions will almost invariably afford better exposure. It is especially true in the case of the posterior tibial artery where it is tempting to incise directly into the bulge through the belly of the muscles. The usual route skirting the medial head of the gastrocnemius muscle and through the two layers of the soleus muscles is by far the more advantageous.

A word of caution concerning the localization of the hematoma may be appropriate. In at least three instances I have been mistaken in the location of the hematoma, when I have made the incision at what seemed the bulge of the mass and location of the bruit, only to find that the artery at this level was intact and the tissues only moderately infiltrated with blood. The first two I thereupon closed under the impression that the diagnosis was wrong. Both of these patients had to be reoperated and the hematoma was found at a more distal level than originally anticipated. In the third case I carried the dissection distally and came upon the hematoma and the injured arterial segment. This mislocation of the site of the injury can be partially avoided by careful preliminary evaluation of the probable course of the missile tract. In no instance have we diagnosed a pulsating hematoma or arteriovenous communication without finding one. This prompts the advice that the search should be continued, even if there is no arterial injury at the expected site.

When one is operating without the benefit of a tourniquet, even with a preliminary ligation of the tributary artery, one should be prepared for a massive hemorrhage when the blood mass is opened. When the site of the hemorrhage, (the injured blood vessel) is certain, it may be wise to find the artery distal to the point of injury as well as to isolate the nerve at that point. In other cases, one makes a wide incision into the hematoma, scoops out the old clot, and rapidly feels for the source of the bleeding by following the stream of the blood. Bleeding is controlled by digital compression. The vessel is then dissected free in the usual manner; the finger is a guide to the source of the bleeding, and, although it may become rather numb during the ensuing dissection, should remain in place until the vessel is secured.

In no instance have I been able to perform a suture of the artery. This would be the ideal method of handling the situation

but it is rarely possible because of the extensive damage, and the surrounding inflammatory reaction both in the artery and in the surrounding tissues. Microscopic sections reveal a surprising amount of arteritis. I have found that the double ligature above and below with a moderately heavy silk is an adequate method of control. A transfixion suture has been employed in a few cases. The intervening segment is then excised. In one or two patients I have thought it too difficult to excise the arterial segment involved and in these have merely cut the artery between ligatures. It is important that the vessel be transected even if it is not removed, so that it may retract. In every patient we have identified the accompanying nerve, and in two have performed a nerve suture at the same time.

It cannot be too emphatically stressed that both the proximal and the distal side of the vessel must be ligated. In one patient who had twice been operated upon elsewhere for severe arterial hemorrhage from the profunda femoris artery, (with proximal ligature of this vessel in continuity) we had to reoperate and ligate the distal segment. This patient was prepared for surgery only with the administration of 2,000 cc. of whole blood so that the state of exsanguination may be imagined. This patient had received thirty-four transfusions before this operation was performed.

After the artery has been secured the tourniquet is released. This is important for there may be more than one artery injured and actually there may be two pulsating hematomas caused by the same missile. We have seen two such patients, one hematoma in the thigh and one in the leg with both the anterior and posterior tibial arteries injured. When the tourniquet is released there is often a considerable amount of hemorrhage which is probably due in part to the reactive hyperemia. To evaluate such bleeding properly it is wise to place a pack into the wound and wait for five or ten minutes before searching for bleeding points. At this time it will usually

be found that there are several subcutaneous veins bleeding and they can be secured. If there is continued ooze and the source is not easily found, we have found that the use of a light pack and a mild elastic compression bandage is not in the least harmful and does not imperil the collateral circulation. The pack should be loosely placed into the wound and merely acts as an internal splint against which the external compression may act. Before this pack is placed into the wound or before closure we have been frosting the wound with sulfa and urea powder. A compression dressing is then applied.

The postoperative care is most important. Paravertebral sympathetic block is performed as often as is necessary. We believe that it is best to postpone this until the patient has reacted from his anesthetic, although it is tempting to do it immediately, especially when there is an associated fracture. It may even be advantageous to employ double external skeletal fixation of the fracture so that such blocks can be performed. The foot is routinely packed in ice. We have done this with the use of several ice bags. A heat cradle is placed over the abdomen to stimulate reflex vasodilatation. The extremity is usually slightly elevated to avoid venous congestion.

It is most important to keep the blood in good condition. If the extremity is deprived of 50 per cent of the blood supply, and the oxygen carrying capacity of the blood is reduced to 50 per cent, then the nourishment that the extremity receives will be only 25 per cent of normal. Therefore, careful hematological appraisal is most important.

When a pack has been used we have found, to our profound surprise, that it can be left in place for from ten to fourteen days without difficulty, and at that time is easily removed. Clean granulation tissue now lines the entire wound and this rapidly closes the often tremendous cavity. We have removed the pack under pentothal anesthesia so that, should it become

necessary, another may be replaced. In none of the three occasions when a pack has been used, has this been necessary.

The anticipated complications are gangrene, persistent ischemia with claudication, thrombophlebitis and embolism. In only two cases have we had any frank gangrene. One was a popliteal hematoma, with extensive soft tissue and bony damage. The gangrene in this patient was only of three toes. In the patient referred to above for whom the third operation was required to ligate the distal segment of the profunda femoris artery there was gangrene of the toes. At the time of the third operation, however, we had found that there was also a thrombosis of the superficial femoral artery. We have not had the opportunity to follow our patients for a sufficiently long period to observe whether or not the relatively mild ischemia which we have observed will be permanent. Lumbar or stellate ganglionectomy may be considered, if this is the case. It must be remembered, however, that we are dealing with a particularly favorable age group for arterial surgery. It is interesting to speculate what will happen to these patients when they reach the obliterating arteriosclerotic age.

We have so far observed neither thrombophlebitis nor pulmonary emboli. This is somewhat surprising, as in several patients we have found the accompanying vein thrombosed. Perhaps our ligature of the veins prevented these complications. I have had one patient who had a moderately severe secondary hemorrhage. This was found to be from the saphenous vein which had been injured at the time of the operation. In no case have we had any wound infection. This may be due to the local and systemic chemotherapy which we have routinely carried out.

#### SUMMARY AND CONCLUSIONS

1. Pulsating hematoma is a very frequent complicating factor of war wounds. In many instances they palpably pulsate. Their appearance is frequently delayed for

several weeks after the original injury. A theory for this has been propounded.

2. The differential diagnosis between pulsating hematoma and arteriovenous fistula with a false aneurysm has been discussed, and the importance of this differentiation discussed.

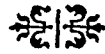
3. Certain factors in the operative technic have been discussed including the use of the tourniquet, the provisional ligature, the management of the patient where these are not possible, as well as the treatment of the injured artery.

4. The postoperative care has been re-

viewed including the necessity for local refrigeration, reflex and paralytic vasodilatation. The utmost importance of keeping the blood at its maximum oxygen capacity has been stressed.

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IF Volkmann's ischemic contracture occurs it should be recognized in its early form and treated immediately by incising the fascia of the forearm in order to evacuate the underlying hematoma. Special splints should be fitted for gradual correction and stretching of contractures. In most instances radical operations are eventually necessary.

From "Fractures and Dislocations for Practitioners" by Edwin O. Geckeler (The Williams and Wilkins Company).



# METHOD FOR REPAIR OF POSTERIOR TIBIAL NERVE\*

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**A**N exact atraumatic suture of freshly viable nerve ends without tension is the principal aim in the secondary repair of a divided peripheral nerve. When exposed for secondary suture the nerve ends are usually separated by a considerable distance due to retraction of the severed nerve. An additional length of the nerve may have been so extensively damaged that excision of a considerable segment will be required before viable nerve tissue suitable for suture will be exposed. When the circumstances of the injury and treatment have precluded primary nerve suture, closing the defect in the continuity of the nerve without tension becomes the paramount problem of the secondary repair. If the defect is overcome by forcefully dragging the nerve through the surrounding tissues and rapidly stretching the nerve, irreparable disruption of the nerve structure in the stretched segment occurs. However, a slow increase in the length of a peripheral nerve can occur without any apparent loss of function. This is not uncommonly demonstrated by the elongation of a nerve in its circuitous route about a tumor.

Secondary suture of a nerve without tension usually requires an extensive exposure and transplant of the nerve to a position where its route is shortened. Transplantation usually includes routing the nerve across one or more joints placed in flexion. After healing has occurred the slow extension of the joint will then be tolerated by the nerve. Although stretching of the nerve by any means and at any time is to be deplored, practically this must be done or the majority of peripheral nerve injuries must be regarded as irreparable. Any stretching should be minimized by the

wide mobilization of the nerve and utilization of the normal elasticity of the greatest length of nerve that can be practically exposed.

By taking advantage of wide mobilization and transplantation most peripheral nerves in the upper extremity can be repaired without excess tension. In the lower extremity repair has been more difficult and particular difficulty has been encountered in closing defects in the posterior tibial nerve in the lower third of the leg.

The posterior tibial nerve is commonly injured by direct trauma in warfare and is also exposed to injury during operative procedures in which hemorrhage from the posterior tibial vessels occurs. Profuse and rather terrifying bleeding can occur from these vessels. They are difficult to expose and during attempts to control bleeding the nerve may be severely traumatized. Injury of the posterior tibial nerve in the lower leg is a disabling injury for loss of sensation on the plantar surface of the foot results. This area is subjected to considerable trauma and temperature change and total loss of sensation often ultimately results in chronic ulceration of the foot and total disability. If sensation sufficient for protection can be regained the nerve repair should be considered worth while. The return of function of small muscles of the foot supplied by the nerve is of less importance than the return of sensation to the foot.

Because of the severe and chronic disability resulting from paralysis of the posterior tibial nerve in the lower third of the leg, a method to overcome the extensive loss of substance frequently found in this nerve was required. Wide exposure of the

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FIG. 1. An incision has been made in the lower third of the leg and the posterior tibial nerve explored at the site of injury. It has been found impossible to close the defect without further mobilization of the nerve, the extension of the incision on the leg and thigh has been marked.

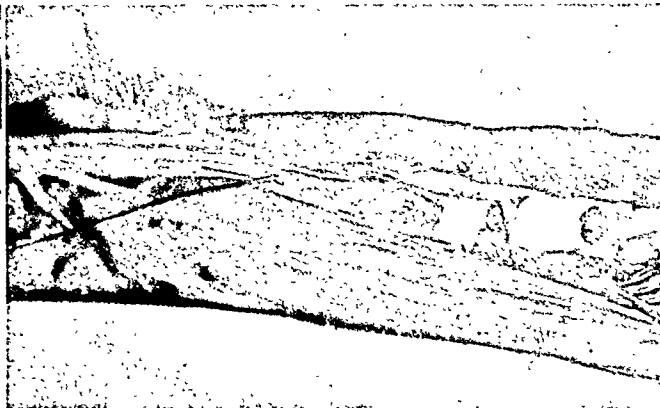


FIG. 2. The divided nerve ends are exposed. Branches from the proximal end to the plantar flexors of the toes and the tibialis posticus muscle are exposed in preparation for their dissection to the level of the popliteal space. The fibrotic nerve ends must be excised before suture which will increase the defect in the continuity of the nerve.



FIG. 3. An interfascicular dissection has released the motor branches of the nerve to the level of the popliteal space. The sensory portion is now free to be transplanted away from the skeletal plane.



FIG. 4. The sensory portion of the nerve can be seen lying superficial to the opened gastrocnemius muscle. An electrode which has been placed on the motor branches to demonstrate stimulation will give unimpaired muscle contraction.

nerve with flexion of the knee did not give sufficient slack in the nerve to close the defects often encountered. Full advantage of knee flexion could not be gained for the nerve was held close to the skeletal plane of the leg at the point it passed beneath the soleus muscle. Bridging the defect in nerves of large diameter by nerve graft has not proved to be satisfactory and it was thought not advisable to resort to this method.

It was found that a satisfactory end-to-end suture without tension could be accomplished by the procedure to be described. Defects of 10 to 14 cm. can be closed and the nerve ends sutured without

tension. The procedure requires an extensive dissection of the leg, fixation of the knee joint in flexion for one month, a prolonged period for regaining extension of the knee. In spite of the potential hazards of these procedures, it is worth while if sensation in the plantar surface of the foot is regained.

An incision is made from the level of the medial malleolus over the route of the posterior tibial nerve on the posterior surface of the leg. The site of injury is exposed and the extent of the defect determined. If the defect between freshened nerve ends is more than 6 cm., transplant of the nerve should be done. The incision is then ex-



FIG. 5. With the knee in a flexed position the ends of the portion of the nerve passing to the foot now show an overlap. The nerve ends can be trimmed and an exact suture accomplished without tension.

tended proximalward medial to the popliteal space onto the posterior aspect of the thigh. (Fig. 1.) The nerve is then isolated in the popliteal space and the branches to the gastrocnemius and soleus muscles exposed. The two heads of the gastrocnemius muscle are separated distally to the tendon; this can be done with only slight bleeding if the site of separation is accurate. The posterior tibial nerve is then exposed to its point of passage beneath the arch of the soleus muscle. Exposure of the nerve beneath the soleus can be accomplished by detaching the muscle from its point of origin on the tibia or by splitting its fibers. Short branches from the posterior tibial vessels enter the muscle and are easily torn if the muscle is retracted posteriorly too vigorously after detachment from the tibia. Profuse hemorrhage can occur from these vessels, therefore, a deliberate and wide exposure should be made in order to insure adequate control of hemorrhage if it does occur. By splitting the muscle it may be necessary to sacrifice the nerve supply to its medial third but from the standpoint of exposure this method is best. It is hazardous to attempt to dissect the nerve from beneath it without clear visualization of the tibial vessels, otherwise one of their branches is almost certain to be torn with an ensuing hemorrhage that is difficult to control.



FIG. 6. Operative incision twelve weeks after operation. Prolonged disuse has resulted in considerable atrophy of the calf muscles. This will disappear as activity increases.

After the posterior tibial nerve is fully exposed the motor branches to the tibialis posticus, the flexor hallucis longus and the flexor digitorum longus muscles can be isolated. (Fig. 2.) The motor branches should be separated from the main portion of the nerve proximalward to the popliteal space in order to obtain sufficient slack in these branches to permit the remainder of the nerve to slide distally. The separation of these branches can be accomplished by sharp dissection for they do not join an intraneural plexus but maintain their integrity as discrete branches as far as the popliteal space. (Fig. 3.) The motor branches are replaced in the original bed of the nerve, the soleus and gastrocnemius muscles are closed and the portion of the nerve supplying the foot is placed superficial to these muscles (Fig. 4.)

It is then found that by flexing the leg on the thigh the nerve becomes slack. (Fig. 5.) The nerve had been retained close to the skeletal plane at the point of passage beneath the soleus muscle and not until it is liberated from beneath this point can the

nerve be routed through the shortest possible distance. It may be necessary to separate the branches to the gastrocnemius and soleus muscles by an interfascicular dissection in order to prevent tension on these branches. Interfascicular dissections can be accomplished without injury if carefully done, for muscle response to electrical stimulation of the nerve is unchanged after completion of the procedure.

Subsequent to nerve suture flexion of the knee is maintained by fixation in a plaster cast for four or five weeks. The foot should be well padded to eliminate pressure points in dennervated areas. Following removal of the plaster cast a period of eight weeks is usually required to regain extension of the knee. (Fig. 6.)

The defects closed by this procedure have been of a magnitude that formerly had been considered irreparable. Though it appears to be a rather formidable procedure it is vindicated if it permits a repair of the nerve to be accomplished. In small defects this extensive dissection is not required. Therefore, the site of injury should be fully exposed and the extent of the defect determined before the full incision is made.

In my personal operative procedures division of the posterior tibial nerve was found in fourteen instances. Eight were explored before this method was used. Of these the defect was greater than 10 cm. in three instances and the nerve was thought to be irreparable. The repair in many of the others was not a source of satisfaction for the knee and ankle were positioned in extreme ranges and even then did not permit suture of the nerve without tension. This was not a good record. Since the method described was devised six

posterior tibial nerves required suture. All were repaired without difficulty and defects varying from 8 to 14 cm. were closed without tension.

#### SUMMARY

Secondary repair of divided peripheral nerves usually requires closing an appreciable gap in the continuity of the nerve. Such defects can be closed by routing the nerve into a more direct course and by taking advantage of positioning one or more joints. The joint is slowly extended to a normal position after healing has occurred.

Injuries to the posterior tibial nerve result in anesthesia of the plantar surface of the foot. This is a disabling lesion. Defects in the posterior tibial nerve in the lower third of the leg are difficult to close. A method is described for transplanting the sensory portion of the nerve from the skeletal plane of the leg, thereby taking full advantage of flexion of the knee. It is possible to close defects of considerable magnitude by this method.

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# SIMPLE TECHNIC OF SUTURING IN GASTROINTESTINAL ANASTOMOSES

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SINCE the beginning of intestinal surgery there have been a multitude of methods of gastrointestinal anastomoses advocated, each of which has been satisfactory in the proper hands. Excluding the use of aseptic anastomoses, there are essentially no new ways. A technic of anastomosis which has been used for the past ten years by the writer is applied so easily and with such success that this report was suggested. It has been used in war as well as in civilian surgery.

"In every intestinal suture certain end results are desired; first, by carefully and closely applied sutures to effect a primary tight closure of the gut lumen; second, by a broad apposition of serous surfaces to bring about organic union as soon as possible; third, to control bleeding of the incised intestinal wall; and fourth, to approximate neatly the cut edges of the mucosa, in order to prevent a subsequent cicatricial stenosis.

"While in most suture procedures the two wound edges are properly approximated without difficulty, the coaptation of the wounds edges by the three-layer suture (mucosa, serosa, muscularis) encounters difficulties both in the closure of lateral or terminal gastro-intestinal openings and in the anterior three-layer suture in entero-anastomosis, because the mucosa has a tendency to evert."<sup>1</sup>

The technic described below obviates just the difficulties mentioned without requiring the use of special instruments or changes in technic.

*Technic.* The loops of bowel to be anastomosed are first fixed side by side either with clamps or stay sutures. A serous layer of interrupted silk or cotton is inserted extending laterally for about

one-half inch beyond the expected end of the anastomotic opening. (Note: The artist has not included this stitch for reasons of clarity.) The bowel is then opened to the desired length and the cut edges caught with Allis clamps. A through-and-through suture from the mucous membrane of one lumen to the mucous membrane of the other, including all the layers of both walls, is inserted in the mid-line. This is tied and a lock stitch begun toward either end, taking in all layers exactly like the first stitch. This may be continued for several stitches before inserting the stay sutures as shown in Figures 1 and 2.

*Stay Sutures.* The stay suture is inserted after grasping the suture edges about one inch above the end of the anastomotic opening, as shown in Figures 1 and 2. This is a single mattress suture beginning on the mucosa of one lumen passing through all layers of both walls and then back to the lumen at the point of entrance where it is tied and cut. It is essential that it be placed anterior to the end of the anastomotic opening as that is the secret of its value. The suture should be inserted about  $\frac{1}{8}$  inch from the cut edge with the arms about  $\frac{1}{2}$  inch apart. This apposes serous layer to serous layer and will not interfere with the continuation of the lock stitch which takes in the same area. (If it is held as a stay suture it will distort the line of suture and will also interfere with the completion of the lock stitch.)

In all entero-anastomoses the stay sutures are inserted about  $\frac{1}{2}$  inch anterior to the angle. (Figs. 1 and 2.) In gastro-enterostomy or subtotal gastrectomy due to the difference in the thickness of the

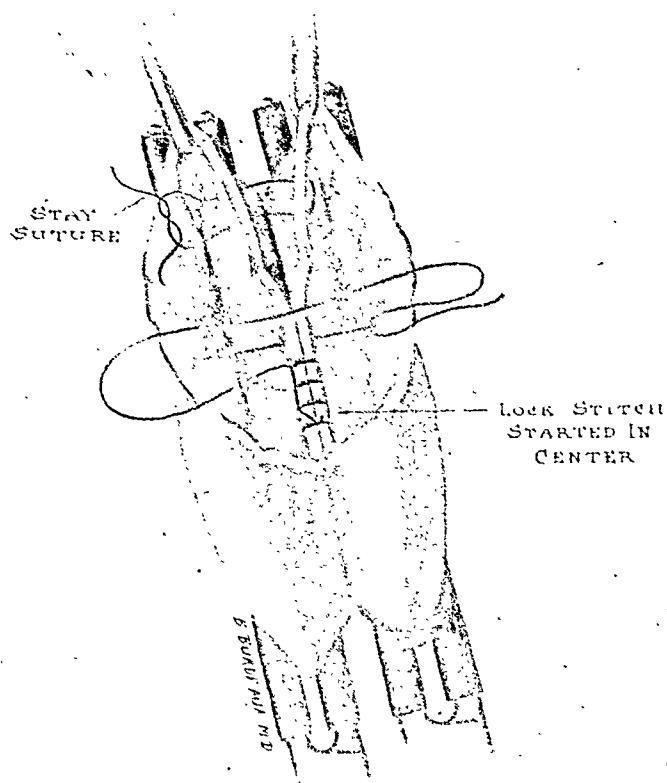


FIG. 1. Lock stitch has been inserted and several stitches taken; stay suture in place prior to tying. Cut shows position of stay suture about  $\frac{1}{2}$  inch above end of anastomotic opening and method of straightening out line of suture by use of Allis clamps on anterior surface.

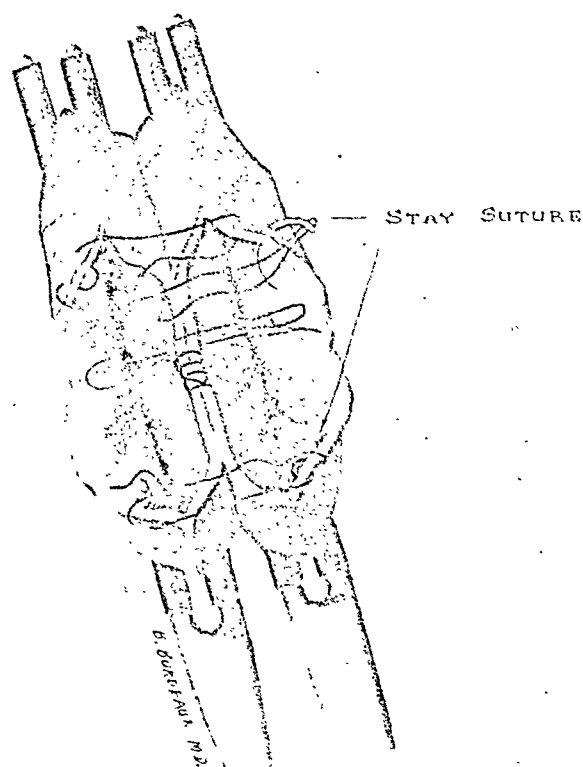


FIG. 2. Similar to Figure 1 except both stay sutures are in place prior to tightening. Position of stay sutures in relation to end of incision in bowel is shown. Necessity for traction prior to insertion of stay sutures is demonstrated by comparing with Figure 1.

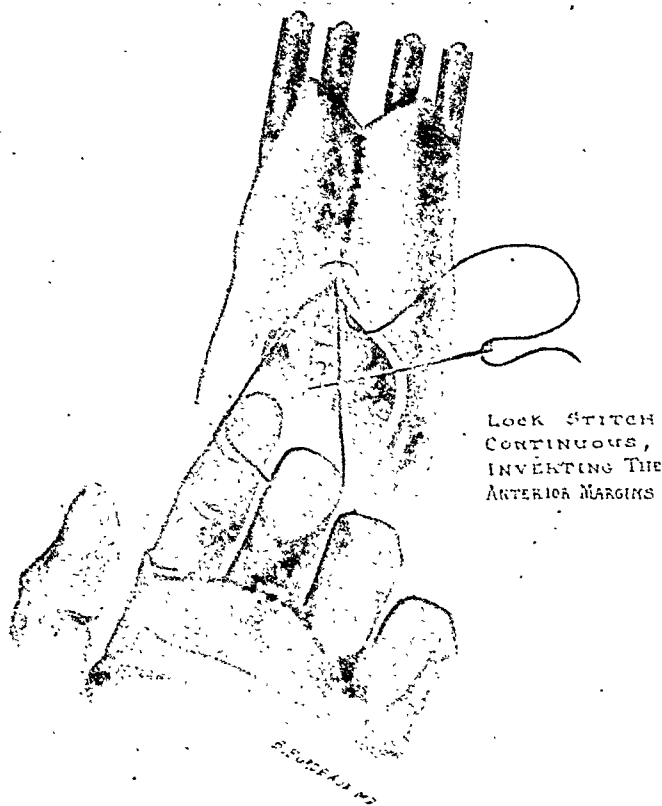


FIG. 3. Allis clamps removed permitting suture line to fall in place. Method of tightening lock stitch in lumen is shown.

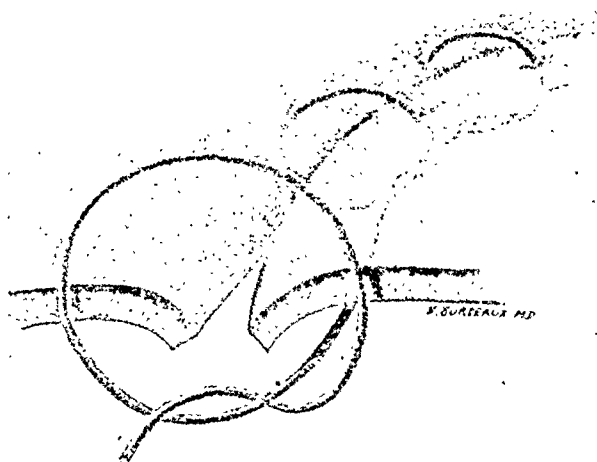


FIG. 4. Graphic illustration of lock stitch as visualized by the artist.

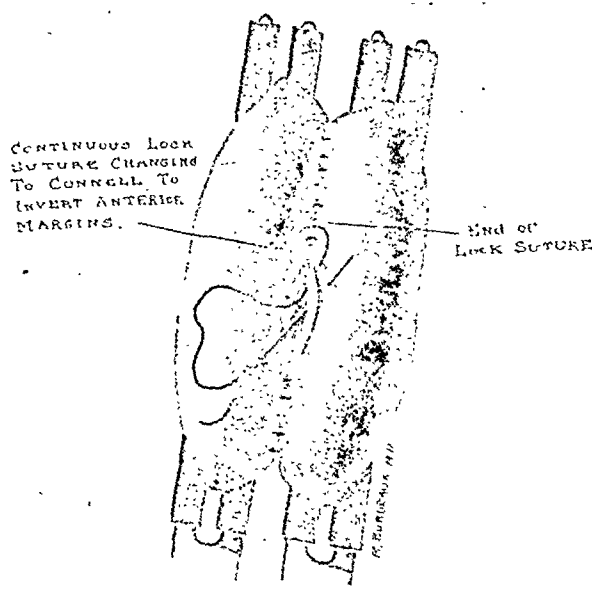


FIG. 5. Cut shows lock stitch completed and method of changing to Connell stitch for complete closure. One suture has been omitted for clarity.

apposing walls, the stay sutures are placed at the angle but always on the anterior side as indicated in Figures 1 and 2.

The cut edges about 1 inch anterior to this stitch are then grasped with Allis clamps and the line to be sutured straightened out as shown in Figure 1. The lock stitch is then continued until the edge of the clamps is reached. On release of the Allis clamps the picture presented in Figure 3 is seen with the angle completely covered over and the end of the

suture line lying anteriorly and well toward the mid-line. The appearance of the suture line and method of locking are shown in Figures 3 and 4.

This anterior line is continued as far as desired and then the other end treated in the same way as shown in Figure 2. Both stay sutures may be placed at the beginning of the lock suturing or one end may be completed first. Figure 5 shows the appearance of the anastomosis just prior to the final completion. (The artist has omitted the end of one suture

for clarity.) The locked "lumen" suture cannot be used without causing roughness in the final  $\frac{1}{2}$  inch of closure and, therefore, two or three Connell sutures as shown in Figure 5 complete the anastomosis. (Note: The writer prefers the use of a curved needle instead of the straight needle shown in the cuts. It is also his custom to tighten each lock stitch himself as failure to do so may result in a weak spot.)

At this point, clamps if used, are removed and the suture line inspected for bleeding or weak areas. These are taken care of by a few mattress sutures and the anastomosis then completed by a continuation of the serosal stitch of interrupted cotton or silk. At the time of inspection it will be noted that the serosal layer is smooth and that there are no weak points in the angles.

In stomach or large bowel anastomosis the writer uses a third seromuscular layer of continuous catgut between the serous and mucous layers.

#### SUMMARY

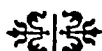
1. A simple technic for intestinal anastomosis is presented in which a continuous lock stitch is used for the mucous layer. The use of stay sutures above each angle allows this to be inserted with ease.

2. It obviates the difficulties encountered in the closure of lateral or terminal gastrointestinal openings and in the anterior three-layer suture in entero-anastomoses. It is applied easily and requires no special instruments and no changes from the ordinary technic.

3. It affects a primary tight closure of the gut lumen, apposes serous surfaces, controls bleeding of the incised intestinal or stomach wall and approximates neatly the cut edges of the mucosa as postulated above.<sup>1</sup>

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# REDUCTION OF RECTAL PROLAPSE

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A SEARCH of ten years of American literature reveals a preponderance of information on the treatment

of gr.  $\frac{1}{6}$  hypodermically, an oval-shaped placental forceps with a well lubricated ball of cotton was inserted through the

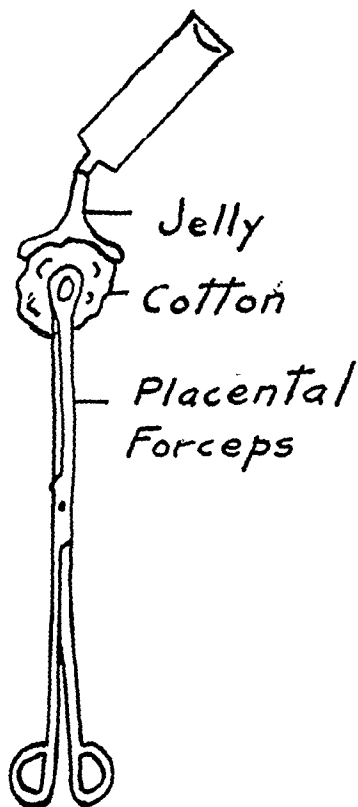


FIG. 1. Placental forceps with large cotton ball, well lubricated with jelly.

of rectal prolapse but little is said relative to reduction. Reduction by manual manipulation and by the index finger covered with gauze, cotton or paper is described. The method reported in this paper has been successful after failure with the above methods.

Recalling the lectures of E. G. Martin on the initial phases of rectal prolapse (exaggeration of the normal colorectal intussusception), it seemed mechanically more sound to reduce the prolapse from above the ring of constriction rather than manipulate the protruding mass from below. After the administration of papaverine gr.  $\frac{1}{2}$  intravenously and morphine

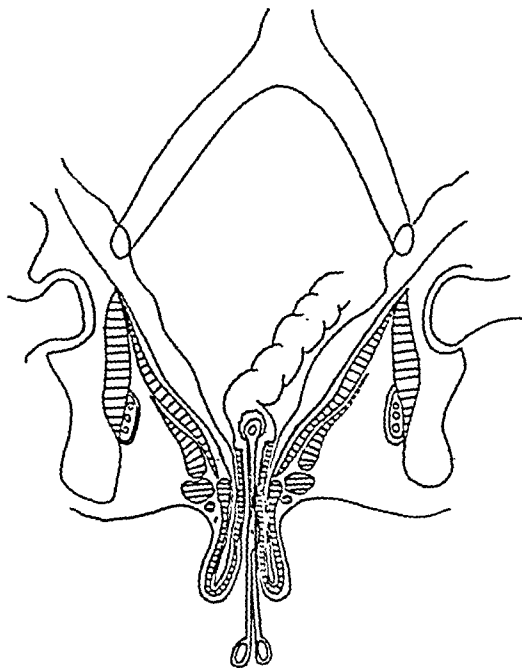


FIG. 2. Placental forceps in place beyond the ring of constriction at angulated sigmoid.

constricted ring to the angulated portion of the sigmoid. The lubrication prevented traction on the edematous mucosa at the constriction. The reduction occurred almost spontaneously without the need of force. This experience has been repeated in six cases.

The method is of advantage because it avoids trauma to the already devitalized bowel. The ease of reduction following the introduction of the forceps is most gratifying. The need of postponing reduction until the subsidence of edema by the use of hot packs or adrenalin is obviated. Gangrenous bowel should not be replaced.

In conclusion, a non-traumatizing method for the reduction of rectal prolapse is reported. There is probably nothing original in this method yet it has not become common knowledge.

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# Case Reports

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## GLÉNARD'S DISEASE (GENERALIZED VISCEROPTOSIS)

### THE IMPORTANCE OF SOME OF ITS COMPLICATIONS

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IN 1886, Frantz Glénard<sup>1</sup> published an admirable work on the subject of generalized visceroptosis as a clinical entity. Although antedated by Mosler<sup>2</sup> in 1866, Glénard discussed the pathology and stressed the importance of diagnosis and treatment. He pointed out that a prolapsed kidney was not a disease in itself, but was one aspect of a generalized condition. Stiller<sup>3</sup> considered the condition one of congenital origin, and was of the opinion that an individual with an enteroptosis also had a neurasthenic background. Mathes<sup>4</sup> was particularly interested in the mechanical conditions leading to prolapse, and described the so-called "enteroptotic habitus." Vietor<sup>5</sup> was of the opinion that enteroptosis was the result of an arrest in the development of the embryo, hence, a reversion to a lower type. Roger Glenard,<sup>6</sup> writing some biographical footnotes and a list of his father's publications, emphasized the fact that it was due to his father's work that the right type of abdominal supports and corsets were devised. Since the time of Glénard<sup>1</sup> and Stiller,<sup>3</sup> the literature has become quite voluminous, although of recent years we have learned that symptoms are not commonly preceded by this disease. However, some of its complications are very important and serious; this is particularly true of obstruction (e.g., intestine, ureter, etc.). The condition has been described under such terms as visceroptosis, enteroptosis and splanchnoptosis. Bull<sup>7</sup> is of the opinion that 25 per cent of civilized

people have a generalized visceroptosis, but only a small number of these have symptoms caused by the condition. He states that these patients are melancholic and hyposthenic, hence, might have come under the diagnosis of nervous dyspepsia or nervous gastritis. Moody<sup>8</sup> examined 1,000 University of California students without history of intestinal trouble or chronic constipation, and came to the conclusion that abdominal viscera may function regardless of their position, and that low lying viscera should not be considered the cause of the disorder. It is because of such teachings, that it seems wise to classify Glénard's disease into those cases which produce symptoms and those which are symptomless. In this modern era of psychosomatic medicine, many of the symptom complexes which were previously ascribed to Glénard's disease might be explained on a neurogenic basis. This paper, however, is not primarily interested with the symptoms *per se*, but rather to emphasize the importance of its possible complications.

*Etiology.* The condition has been classified as either of congenital or acquired origin, and a tremendous number of etiologic factors have been named. The cause of the disease has been linked to some hereditary taint, probably affected by lack of physical training or improper diet especially vitamin or caloric deficiencies. The lack of support from adipose tissue has been especially emphasized; the classical

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example of which is the loss of retroperitoneal fat seen in wasting diseases and resulting in nephroptosis. The relaxed abdominal wall due to repeated pregnancies has been suggested as has ascites or the removal of large abdominal tumors. Among other causes the following have been mentioned: trauma, straining, coughing, constricting corsets and belts, pressure from neighboring tumors, prolonged nervous depression, alcohol and lack of exercise. The true cause or causes still remain obscure.

**Symptomatology.** As stated, the condition in the absence of such a complication as obstruction rarely produces symptoms, although not infrequently the patient presents various complaints, many of which appear to be of the psychogenic type. Symptoms such as asthenia, tachycardia, cold clammy extremities, mental depression and anorexia, have been complained of by the visceroptotic. Symptoms referable to the gastrointestinal tract such as vomiting, intestinal stasis and mucus stools have been noted. Although the stomach and colon may be extremely ptotic, no delayed emptying time has been found. Such vague complaints as headache and backache have been attributed to Glénard's disease, but without adequate explanation. Keeton<sup>9</sup> noticed that when a Rehfuß tube was passed and reached the duodenum in a visceroptotic individual, nausea, dizziness, pressure in the head and even syncope resulted. He believed that the nausea resulted from a motor duodenal dysfunction, probably antiperistalsis, and that the other sensations should be regarded as a low threshold of sensibility which permits stimuli from the duodenum to reach the nervous system through the autonomic nerves and there overflow into the vasomotor center. Other complaints which have been attributed to this disease are: low blood pressure, muscular rheumatism, migraine, tinnitus, insomnia, leukorrhea, delayed puberty and menstrual disturbances. There are, no doubt, some cases which

cause symptoms referable to a malplaced organ, but these must be demonstrated.

**Diagnosis.** The diagnosis is not difficult since a study of the type of individual and a physical examination immediately lead one to suspect Glénard's disease. The position of the abdominal organs is readily discovered by x-ray examination, and a flat plate indicates a ptotic kidney, liver or spleen. Beilin<sup>10</sup> emphasized a fluoroscopic diagnostic sign in which these individuals exhibit symptoms on a full stomach while in the upright position. These are immediately relieved when the abdominal wall is elevated manually and the patient is placed in the Trendelenburg position. The diagnosis of visceroptosis *per se* is in itself an easy one, but whether or not the ptotic condition of the organ is the cause of the symptom complex is another story. Again, we repeat that a localized ptosis with a specific localized symptom complex seems much more convincing than the numerous complaints which one might find associated with generalized visceroptosis.

#### CASE REPORT

Patient No. 24898 was a thin, white female, forty-nine years of age, who was admitted to the Cook County Hospital May 16, 1938, with a history of severe abdominal pain. She stated that she awoke that morning feeling well, had her usual small breakfast followed by a bowel movement, and went to work. At 9:30 A.M., she began to have cramping abdominal pains which were most marked on the left side. This was rapidly followed by nausea and vomiting; the vomitus consisted of the breakfast previously eaten. She took an alkaline powder but this was immediately vomited. The pains became continuous in nature and by 4:00 P.M., the patient took to her bed. She was examined by a local physician who advised immediate hospitalization. On entrance she had a temperature of 99.6°F., pulse of 88, and respiration of 22; her blood pressure was 126/86. Physical examination revealed a very distended abdomen with the umbilicus well above the xiphopubic line. Although there was no rebound tenderness there was some muscular defense and local tenderness in both the left lower and upper quadrants. Ab-

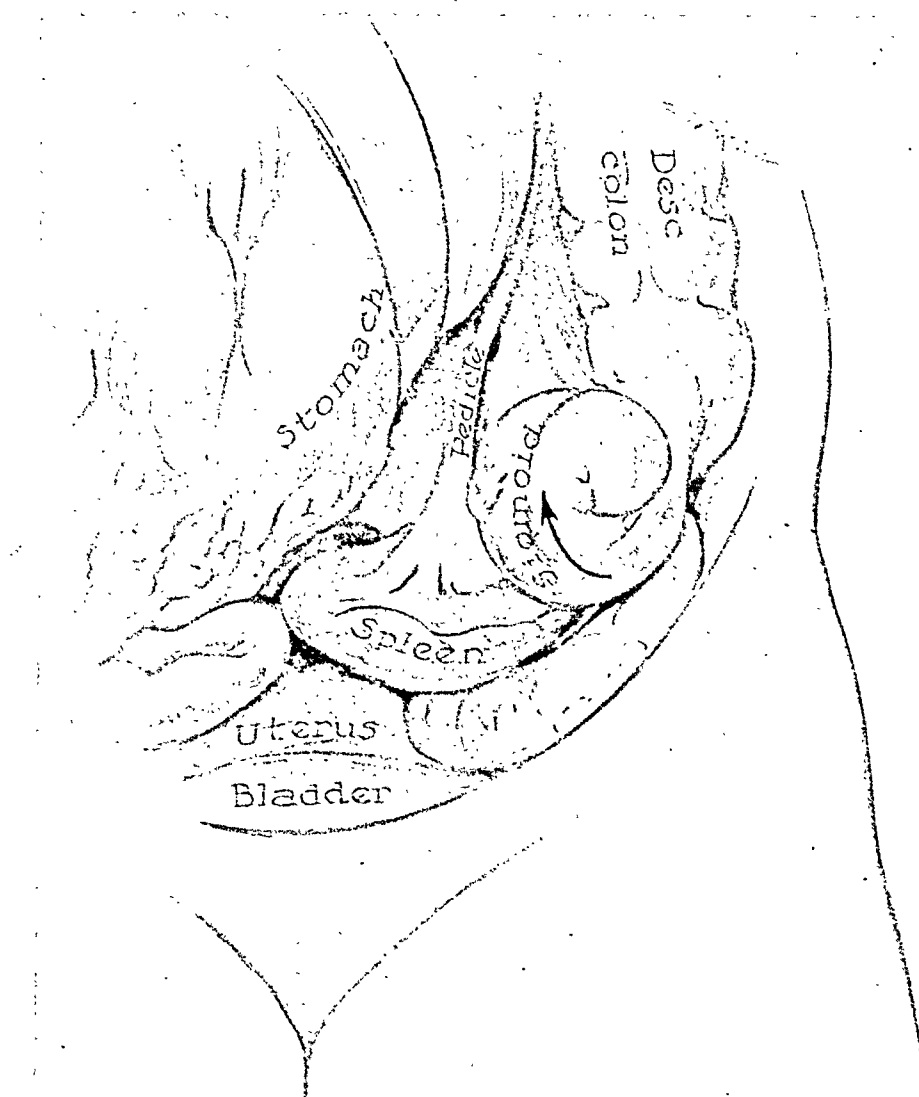


FIG. 1. Drawing of conditions found at the operating table. The sigmoid rotated 180 degrees clock-wise in a groove bounded medially by a tremendously elongated splenic pedicle. The position of the spleen in the true pelvis, covering the left ovary and tube, should be noted. The stomach, too, was extremely ptotic as were all the other organs in this case of Glénard's disease. As soon as the splenic pedicle was severed and the spleen removed, detorsion of the twisted sigmoid became possible. The bowel was not viable and had to be resected.

dominal auscultation revealed that the bowel sounds were definitely decreased in rate and somewhat metallic in quality. A mass about the size of a fist was palpable to the left of the umbilicus which seemed soft to the touch and was exquisitely tender. Rectal examination revealed no masses or fecal material on the examining gloved finger. At 7:30 P.M., of the same evening the patient was sent to fluoroscopy where a definitely distended portion of left colon was seen which was filled with gas. There was no visible small bowel paralleling and no pneumoperitoneum. Barium was given per rectum and this was followed to the rectosigmoidal junction where it abruptly stopped.

The roentgenologist diagnosed a large bowel obstruction probably produced by a carcinoma of the rectosigmoid.

The patient was prepared for surgery by establishing her fluid, protein and electrolyte balance, and under spinal anesthesia was explored through a left rectus incision. A large gangrenous loop of sigmoid was found which had turned 180 degrees clock-wise. (Fig. 1.) Attempts at detorsion were impossible since the gangrenous segment seemed to be held by a band or pedicle which extended from the left upper quadrant to the left broad ligament. It was difficult to identify this band anatomically. Pelvic exploration revealed a spongy soft mass



FIG. 3. Same case after reduction of prolapsed bowel followed by an end-to-end anastomosis.

in the region of the left ovary and tube. The mass was at first thought to be due to an old adnexitis with an encapsulated hematosalpinx. The previously described band was firmly attached to this mass. On attempting to mobilize and remove the mass, a rather extensive hemorrhage resulted and closer inspection revealed that an ectopic spleen had been injured during the attempt at mobilization. The band which ran from the pancreatic region to the pelvis was then identified as a tremendously elongated splenic pedicle, containing the splenic vessels, which formed a groove in which the ptotic and redundant sigmoid became twisted. This pedicle was severed and ligated and the pelvic spleen removed. It was then easy to detort the gangrenous sigmoid, but the black bowel was definitely not viable and had to be resected. This was accomplished by means of a modified Mikulicz exteriorization procedure making an elongated spur between the afferent and efferent loops which resulted in a double barrel colostomy. Because of the poor condition of the patient, it was thought best to exteriorize rather than perform an anastomosis. The wound was closed in layers and following a very stormy course, the patient was discharged two months later, with a well functioning colostomy. She was told to return in six weeks but she returned in six years.

On October 17, 1944, she was readmitted to the hospital stating that she had led a fairly comfortable life, but about one year after surgery she noticed some prolapse of the colostomy. She was able to replace this, however, but as the years went on the prolapse seemed to get larger and larger. For the past few months she had some difficulty in replacing the bowel. The amount of prolapsed mucosa greatly increased in size and was not entirely reducible. The herniated redundant mass had become so large that she had to wrap it in a towel and then would go to work in this condition. She had been on a full diet with normal stool passages through the prolapsed colostomy. Physical examination was essentially negative with the exception of an extreme prolapse of the colostomy which almost reached the patient's left knee. (Fig. 2.) She was placed on sulfasuxidine, had repeated transfusions and was prepared for surgery. She was reoperated on November 6, 1944. Under spinal anesthesia it was possible to reduce the prolapse; a circular incision was made around the colostomy and both stomas were mobilized. A stricture of the sigmoid was found distal to the distal colostomy opening; the stricture was cut. The edges of both proximal and distal stomas were freshened and an end-to-end anastomosis performed using a two-layer interrupted cotton technic throughout. The patient had a smooth postoperative course and was discharged on December 13, 1944, with the wound healed and having normal bowel movements through the anal orifice. (Fig. 3.)

*Treatment.* The treatment aims at the correction of a localized ptosis. If it can be proven that a dropped kidney is the cause of a symptom complex, a nephropexy is indicated; the same rationale would apply to any other ptosed organ. Other than this, an attempt should be made to increase the patient's weight, muscle tone and caloric and vitamin deficiencies. Some authorities have faith in mechanical devices to assist in support of the abdominal organs. Physiotherapy, massage, graduated exercises and the tonic effects of heat and cold all have their advocates. Psychotherapy is coming to its own in the nervous manifestations associated with malnutrition and viscerop-



FIG. 2. Same case as Figure 1. Extreme prolapse of colostomy following modified Mikulicz procedure for gangrenous sigmoid. The patient failed to return as instructed for repair of the colostomy. Instead of returning in six weeks she returned six years later with this unusual condition.



tosis. In general, the treatment is purely symptomatic and empiric unless definite localized pathology is found with a given syndrome.

#### SUMMARY

Glénard's disease should be repopularized because of the complications which might arise from it rather than the symptoms with which it has been associated. The various torsions with the resulting impairment of blood supply should be stressed, since these are more likely to occur in the presence of elongated mesenteries and redundant segments of bowel. In the case here reported, a gangrene resulted from a volvulus of a redundant sigmoid. Another complication is the ectopic position of various organs which might produce symptoms or may be of interest in that they produce diagnostic difficulties. The tendency towards prolapse must also be kept in mind; in our case the proximal end of a double barreled colostomy prolapsed almost to the patient's knee. Although generalized visceroptosis is unassociated with symptoms in most instances, it nevertheless must be stressed that the condition predisposes an individual to im-

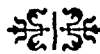
portant and even urgent complications which may require immediate surgical correction. The visceroptotic habitus should call these facts to the surgeon's mind so that during operative procedures he may take this into account and attempt to utilize some prophylactic measures if deemed advisable.

#### CONCLUSIONS

1. Symptoms associated with Glénard's disease are not due to the condition itself, but rather to its complications.
2. The most common complications producing symptoms are volvulus, ectopic positions of organs and obstructions such as those produced by kinking of the ureter, bowel etc.

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# MANAGEMENT OF MULTIPLE COMPOUND FACIAL WOUNDS CAUSED BY WHIRLING AIRPLANE PROPELLER\*

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THIS case report, illustrating the management of severe, multiple, compound facial wounds, is presented to outline the care of patients who are the unfortunate victims of a now relatively rare source of trauma that may be seen more often in civilian practice in the coming "air age," i.e., wounding by a whirling airplane propeller. One's first reaction is to wonder how anyone could innocently walk into a whirling propeller; yet this is not hard to understand if one realizes that in operations on a military field the noise prevents one hearing an individual plane engine, and the speed of the propeller makes seeing it difficult. This patient, who is an intelligent aviation mechanic with long experience aboard a carrier operating in battle areas, was keenly alert to the dangers of his job. Following this accident he did not remember walking into the propeller, though his recollection of events immediately prior to the accident was clear.

The special considerations in the repair of facial injuries have previously been outlined by the author.\* The aims to strive for are (1) primary healing of the injured tissues without infection; (2) preservation of all vital tissue; (3) prevention of stitch marks; (4) avoidance of secondary surgical scarring by débridement or badly placed relaxing incisions. Débridement in facial injuries must be conservative. A few mm. of tissue lost from the tip of the nose, the angle of the mouth, or the canthus of the eye may mean painful and costly subsequent repair, permanent disfigurement or both. Not

1 mm. of potentially viable tissue should be sacrificed at the primary repair. Doubtful tissue should be treated as viable, and every attempt should be made to conserve it by warm packs, supportive dressings and the avoidance of further traumatization by tight sutures.

## CASE REPORT

J. I. C., a white male, twenty-six years of age, was an aviation radioman, second class, USNR. On March 29, 1944, this patient, while working on an airplane, walked into a whirling propeller which struck him across the face and immediately rendered him unconscious. First aid was administered at the air field, and the patient was given  $\frac{1}{4}$  gr. morphine and one unit of plasma intravenously en route to the U. S. Naval Hospital, Oakland. He arrived at this hospital two hours after the injury, having regained consciousness shortly before arrival.

Physical examination immediately after arrival revealed an acutely injured patient, though he was rational and cooperative. The axillary temperature was 96°F; pulse 108 per minute, full, strong, and regular; respirations 28 per minute, labored. Color was slightly cyanotic. Blood pressure was 102/72. The head was swathed in bloody bandages on removal of which the following injuries were noted: a semi-circular laceration through the left eyebrow extended down to and exposed a fracture of the frontal bone. The pupils were contracted, and the patient complained of blurred vision in the left eye. There was a laceration beginning on the dorsum of the nose, and extending through the right alar, the floor of the right nostril, and the right upper lip. The patient was edentulous in the upper mouth, and was wearing an upper plate which was fractured by the accident and had been removed. There was a laceration completely through the lower lip with disruption of the symphysis of the mandible and loss of several teeth. The right arm was

\* The opinions and views set forth in this article are those of the author, and are not to be considered as reflecting the policies of the Navy Department.

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FIG. 1. Condition of patient on admission. A laceration of the left supra-orbital region exposes a fracture of the frontal bone. The wound of the face extends completely through the right alar, the floor of the nose and the upper lip. The wounds of the lower jaw extend through the mandible into the floor of the mouth with disruption of the symphysis mandibulae.



FIG. 2. B, x-ray of the condyles shows horizontal fractures through the base of both condyloid processes.



FIG. 2. A, x-ray of the mandible shows severe comminuted fracture throughout anterior portion with considerable loss of bony substance on both sides of the symphysis.

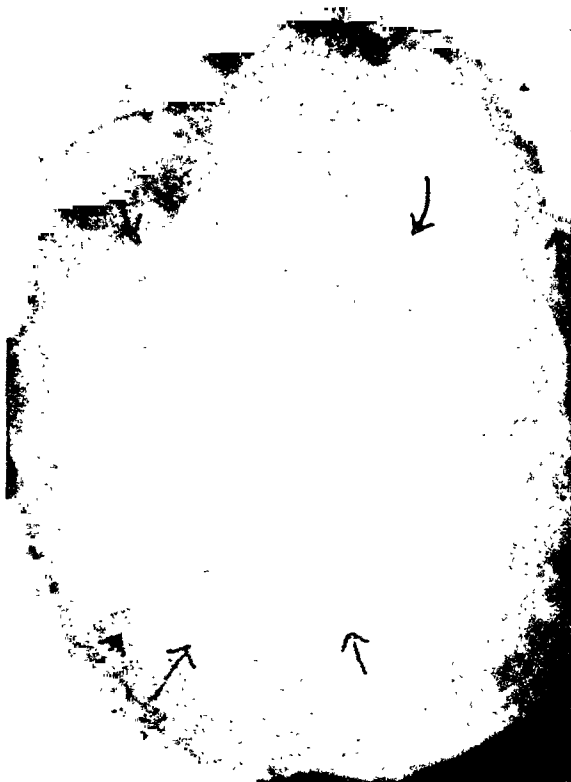


FIG. 2. C, x-ray of the face and skull reveals: (1) fractures of the inner and outer plates of the left frontal bone with extension into the medial portion of the roof of the orbit; (2) comminuted and depressed fracture of the left infra-orbital ridge; (3) oblique fracture of the right infra-orbital ridge with extension into the lumen of the right maxillary sinus.



FIG. 3. The acrylic intra-oral splint in place. Though the patient was edentulous in the upper jaw, satisfactory immobilization was obtained. The incisor teeth shown here were devitalized and were later extracted, but were utilized for immobilization of the lower fragments until union occurred.

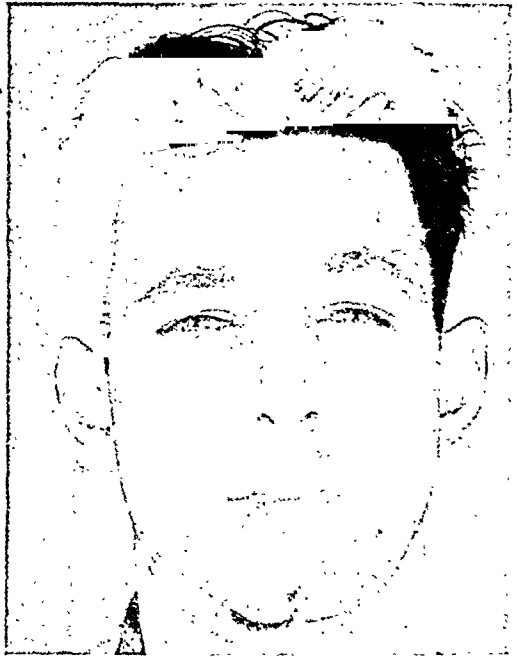


FIG. 4. Early healed condition of patient. The right alar and the vermillion borders of both upper and lower lips were notched. The scars over the mandible were depressed and were densely adhered to the underlying bone. The black area on the chin is whiskers growing in a deep scar.



A

B

FIG. 5. A and B, condition of patient on discharge, following revision of facial scars, and multiple "z" plastics to correct notching and ectropion of the lips.

encased in a board splint. On removal of this splint a wound was seen over the head of the radius. The patient was unable to extend the fingers, and had anesthesia over the dorsum of the thumb. The other extremities were normal.

The following immediate treatment was given: The wound on the right arm was cleansed, dusted with sulfanilamide crystals, dressed, and replaced in a padded basket splint. The patient was given intravenously  $2\frac{1}{2}$  Gm. of sulfadiazine and two units of blood plasma. The wounds of the face were carefully cleansed of foreign material, were washed with white soap and water, and were irrigated thoroughly with sterile saline solution. Under local analgesia a conservative débridement was performed, bleeding points were carefully ligated, and the wound edges were then closed accurately with fine dermal sutures. The mandible was supported by a Barton type head bandage. The patient was experiencing no difficulty in respiration, and was conscious and cooperative. During the night he vomited about 500 cc. of bloody stomach contents. After this he slept well, and the following morning was conscious and cooperative. He was given 500 cc. of whole blood and a booster shot of tetanus toxoid.

The following day the general condition was improved. A portable x-ray was taken of the right arm, and revealed a compound, comminuted fracture of the upper third of the right radius with moderate displacement of the fragments. X-rays of the head revealed multiple fractures of the frontal and maxillary bones, fractures through the neck of both condyles with medial displacement of both condyloid processes and a compound, comminuted fracture of the symphysis of the mandible with loss of approximately one inch of bony substance.

Eye examination revealed 7/20 vision in the left eye with a primary atrophy of the optic disk and loss of the lower field of vision. The eye consultant felt that this was due either to direct trauma or to hemorrhage into the optic nerve.

The patient's general condition improved and by April 16, 1944, both the internal and external wounds of the mandible were completely healed. A week later under local anesthesia the displaced condyles were reduced by intraoral manipulation. An intradental splint was inserted and wired into place to immobilize the jaw. On April 29th, an open reduction of the right radius with fixation by a bone plate was performed by the orthopedic department.

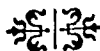
By July 1st, there was clinical evidence of union of the fracture of the symphysis. The intradental splint was removed about once weekly, cleansed and replaced. The patient enjoyed excellent general health.

On August 1st and again on August 17th, cheiloplasty and revisions of the facial scars were done. At this time there was x-ray evidence of bony union of all mandibular fractures. The intradental splint was removed, and upper and lower dentures were fitted. Eye consultation revealed that vision in the left eye had improved to 16/20 and continued improvement was expected. There was firm bony union of the fractured radius, but partial loss of function of the right hand resulted from paralysis of the dorsal interosseous nerve.

On September 22, 1944, the patient was returned to limited duty.

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# LIGATION OF INFERIOR VENA CAVA FOR SEPTIC THROMBOPHLEBITIS\*

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**S**URGERY of the major vessels of the body has received considerable impetus in the past few years from two main factors. One is the treatment of phlebothrombosis by ligation of the femoral and iliac veins and the inferior vena cava. The other is surgery necessitated by vascular injuries in battle casualties. However, there are other reasons for surgery of the vessels which occur infrequently and whose indications are perhaps less clear cut because of complicating factors in the progress of the disease. Septic thrombophlebitis may be such a condition.

Schall reported three cases in which the patients were suffering from cavernous sinus thrombosis with staphylococcal bacteremia successfully treated by sulfathiazole and heparin. Lyons had previously reported such a case similarly and successfully treated.

Kern and Berman have reviewed the historical development of ligation of the inferior vena cava and then reported a case of pneumonic thrombophlebitis with septicemia, inferior vena caval ligation and recovery.

In Homan's excellent review of medical progress in diseases of the veins he discusses some of the problems of thrombophlebitis which are still in question and states clearly that the site of ligation, the time of operation, the type of operation, as well as the postoperative therapy are difficult to decide upon and are not clearly settled as yet. O'Neill points out the difficulty of locating the exact site of a thrombosis and suggests when in doubt the highest possible ligation compatible with adequate venous return.

Bancroft carefully analyzes the difference between phlebothrombosis and thrombophlebitis and emphasizes the different incidence of pulmonary emboli in the two conditions. Lam and Hooker discussed the embolic complications following 100,000 operations and the types of treatment including anticoagulants and vein ligations. Gaston and Folsom report two cases of ligation of the inferior vena cava below the renal veins which effectively prevented further pulmonary infarction. They gave a detailed discussion of the postoperative care which they believe is necessary following this procedure.

Fraser describes a case of ligation of the inferior vena cava associated with penetrating wounds of the stomach, duodenum, lung and extremities from which the patient recovered. He pointed out that a competent collateral circulation developed within a month.

## CASE REPORT

This twenty-eight year old, white soldier was wounded in action by enemy sniper bullet on May 16, 1945, in Luzon, P.I., sustaining severe lacerated wound of right buttock, a comminuted compound fracture of the right ilium and lacerated wound of the right knee. Wounds were débrided and dressed and six weeks later he was evacuated to the U.S. On arrival examination showed an emaciated, bedridden patient with granulating wound of the right buttock. X-ray of the pelvis showed a detached fragment from the anterior superior lip of the acetabulum. On July 31st, the patient developed "new" tertian malaria for which the usual atabrine therapy was instituted. On August 6th, the sinus was explored and sequestrectomy of the right ilium was performed. Drainage continued so that

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FIG. 1. The black arrow indicates the site of ligation of the inferior vena cava. The vein has been opened proximal to this showing the thrombus. Note the incision on the right lateral thigh.

resaucerization was done on August 18th and September 3rd. On October 29th, a split thickness graft was applied to the defect in the right buttock. His postoperative course was uneventful and the wound healed without further surgical intervention. On November 27th, the patient left on a convalescent furlough.

On December 6th, he became suddenly ill with severe chill followed by malaise, weakness and productive cough with much tenacious sputum. He was admitted to this hospital on December 10th with temperature 98°F., pulse 76 and respiration 18. Physical examination revealed dullness, bronchial breath sounds and moist râles in the left anterolateral chest region. X-ray showed a faint clouding in the left lower lung held. A diagnosis of primary atypical pneumonia was made and penicillin therapy was instituted. Chest x-ray on December 21st was normal and the patient was given medical clearance and transferred to the orthopedic service on December 28th.

On December 29th the temperature rose to 102°F. and profuse drainage was present in the iliac wound. A firm mass was felt in the right pelvis on rectal examination. On January 4, 1946, exploration of the sinus tract in the right ilium was made and some drainage was established. His progress was satisfactory until January 20th, when he began to complain of pain in the right loin. Urine showed no abnormalities. Pelvic x-rays showed a well healed fracture of the inferior portion of the right sacroiliac joint with loss of bony substance.

The x-ray of kidney, ureter and bladder showed nothing abnormal. Intravenous pyelogram showed a non-functioning kidney. On February 5th, there was temperature of 103°F., severe pain in the right groin, flexion contracture of the right hip, swelling in the right lower quadrant and below the inguinal ligament. It was believed the patient probably had a retroperitoneal abscess involving the psoas muscle. At this time urine was normal. The red blood count was 3.33 M., the hemoglobin 11 Gm. and the white blood count 10,400 with 85 per cent polymorphonuclears. On February 6th, through a high right inguinal incision an exploration was done into the retroperitoneal region and down to the psoas muscle in the groin and nothing was found. The old wound was also negative to exploration.

Following this procedure the patient started to run a septic course with chills and fever to 103°F. daily. On February 6th, blood cultures were reported positive for aerobacter cloacae. On February 7th, the patient began to develop edema of the right thigh which increased in the next four days until it involved the scrotum and the thigh down to the knee. Therapy at this time consisted of daily blood transfusions, parenteral fluids and 200,000 units of penicillin. On February 9th, streptomycin was obtained and started in doses of 1 Gm. per day. On February 11th, because of extreme edema of the right thigh, medial and lateral incisions were made in the thigh to relieve the swelling and search for possible deep abscess. On February 12th, a



FIG. 2. The groove director is in the left renal vein. The probe is in the right renal vein. The tissue forceps are placed at the site of the ligation. The vein is opened showing thrombus well beyond the level of the renal veins.

paravertebral block was done at the second and third lumbar spaces with 10 cc. of 1 per cent novocaine at each site. The edema began to subside soon after operation and in the next few days disappeared entirely.

The patient continued to run a febrile, septic course with chills and positive blood cultures with gradual loss of strength and evidence of toxemia. Urine remained normal until March 1st, when it regularly revealed presence of albumen (1+) and numerous white blood cells. Red blood cells averaged about 4.0 M with 14 Gm. hemoglobin. White blood cells ranged from 18,000 to 24,000 with 80-90 per cent polymorphonuclears. Blood non-protein-nitrogen was 24 to 29. Total protein 6.0, albumen 3.9, globulin 2.1 and A/G ratio 1:8:1.

On February 28th, it was noted the saphenous veins and its tributaries were somewhat tender and distended. Subsequently the patient developed some edema of the left thigh, the liver became larger, extending three finger breadths below the costal margin; the abdominal veins became prominent, but the spleen was never felt.

On March 6th, because the left femoral and iliac veins were obviously involved in a septic thrombophlebitis and probably the inferior vena cava as well, the decision was made to ligate the inferior vena cava. This was done on March 7th, at which time the patient was seriously ill with chills, fever up to 105°F., pulse 140, and respiration 30. Following the ligation the old incision in the right thigh was

drained by blunt finger dissection and about 75 cc. of pus evacuated.

Following operation the patient developed moderate edema of the chest wall and left lower extremity and slight edema of the right foot. Despite persistently positive blood cultures for aerobacter cloacae, definite clinical improvement was noted for four days with slow decrease in temperature levels, improvement in strength, color and appetite. On March 12th, however, the patient became cyanotic and dyspneic with bilateral chest râles, respirations of 28 and pulse 110 to 140. Urines showed persistent albumen (2+) with many red blood cells and white blood cells. Other laboratory findings were: red blood cells 4.26 M, hemoglobin 14 Gm., white blood cells 18,990, 91 per cent polymorphonuclears, icterus index 16, hematocrit 45 mm., total proteins 6.4, albumen 4.5, globulin 1.9, A/G ratio 2.3:1. It was believed that cardiac failure was not present since the dyspnea, cyanosis and pulmonary edema rapidly disappeared with an oxygen tent and reduced fluid intake. Nutrition was maintained with plasma, amigen and glucose. On March 13th, his condition again became worse as he became stuporous, semicomatose, with fall in temperature and blood pressure and rise in pulse to 150. His condition rapidly declined and he died on March 15, 1946.

An autopsy was performed with the following significant findings. There was a large retroperitoneal pelvic abscess on the right side at the site of the old wound and the ureter was

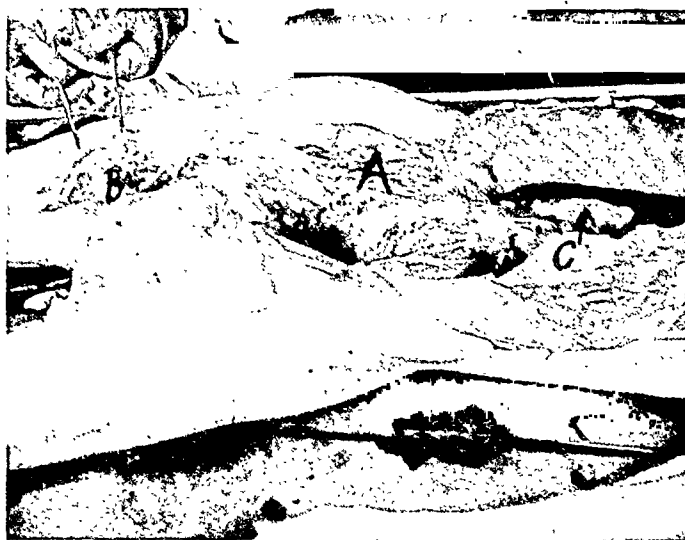


FIG. 3. A is the site of the abscess in the original wound extending posteriorly into the sacral region. B is the abscess cavity where the leg was incised medially. C is pus which escaped from cavity A when it was opened.

involved with an inflammatory stricture resulting in a pyelonephritis. The right iliac and femoral veins were solidly filled with old, organized, infected thrombus extending down into the right thigh which was deeply abscessed around the deep and superficial femoral veins. The left iliac and femoral veins were also solidly involved with a septic thrombus which was purulent in character. The thrombus extended up into the vena cava and tapered off about 5 cm. above the ligature at the end of the renal veins. On opening the cranium an extensive basilar meningitis was present. All these foci returned pure cultures of *aerobacter cloacae*. The other organs showed toxic changes but were not abscessed except for the right kidney which contained multiple miliary abscesses.

#### COMMENTS

There are several features of this case as it progressed which warrant considerable thought, including the long proven maxim that hindsight is better than foresight. Here was a patient convalescing at home from a gunshot wound of the right buttock and sacrum who suddenly became ill with what proved to be primary atypical pneumonia. In reviewing the history with the patient and the doctors in charge of the case at that time there is nothing to indicate that this was pulmonary embolus and he made a normal recovery from the

pneumonia. Then, early in January, possibly because of the lowered resistance from his recent pneumonia, the sinus in the right sacral region began to show signs of increased activity and drainage. On January 4th, the sinus was explored to create adequate drainage and the patient's temperature returned to normal and his convalescence continued satisfactorily until January 29th. At this time he began to complain of pain in the right groin and hip. There was some induration above the inguinal ligament and a slight elevation of temperature.

On February 5th, there had been considerable increase in these symptoms and he was taken to the operating room where a right inguinal incision was made and the retroperitoneal region explored, including the iliac muscle. Induration was present but no abscess and drains were placed in the wound. On February 6th, a blood culture was positive for *aerobacter cloaca*. This organism was found *in vitro* to be resistant to sulfonamides and penicillin, but 0.5 microgram of streptomycin per cc. agar inhibited its growth. He was put on 1 Gm. of streptomycin per day. Laboratory tests showed that 1 cc. of blood diluted five times would inhibit the growth of the organism so that the patient was con-



sidered to be getting adequate therapy. He had no more chills and blood cultures were negative, but on February 10th, he developed marked edema of the right thigh and scrotum and on February 11th, it was so severe that it was decided to operate for two reasons: One was that there was a possibility that he had a deep abscess of the thigh which, by pressure, was impairing the circulation. Secondly, it was believed that longitudinal incisions would relieve the tension in the thigh. We also realized that he probably had a thrombophlebitis of the pelvic vessels and the right femoral vein but did not anticipate a ligation because the streptomycin seemed to be quite effective. At operation no abscess was found, only edema, and the swelling subsided quite rapidly so that five days later the right thigh and leg were back to normal size. On February 19th, the laboratory reported that it now took 3.0 micrograms per cc. of agar to inhibit the bacterial growth and that the blood cultures were again positive. In ten days the resistance of the organism had increased six-fold. In spite of this, however, the patient seemed to be gaining slightly and the temperature was tending to go down. On February 22nd, the streptomycin was increased to 1.5 Gm. and he had no more chills. Blood cultures, however, were still actively positive. On February 28th, March 1st and 2nd, his temperature had come to a fairly normal range. By this time he was draining a lot of thick, white, mucilaginous pus from the inguinal incision and both thigh wounds. On March 3rd, he began to complain of pain in the left groin and calf and it was believed that he was developing a thrombophlebitis of the left leg and pelvis. This continued to progress and it was agreed that the process had probably involved the venous system of the left side up to the vena cava and, furthermore, that he was too sick to survive much more of this septic process.

A ligation of the inferior vena cava

seemed to offer the only prospect of slowing this insidious but relentless organism. At this time the laboratory reported that 40 micrograms per cc. of agar were necessary to inhibit its growth.

The patient was given a spinal anesthetic augmented with sodium pentothal for amnesia. The right side was prepared after sealing off a draining sinus at the anterior superior iliac spine with a collodion dressing. A right lumbar incision was made between the twelfth rib and iliac crest, and the dissection carried through the lumbodorsal fascia to the peritoneum. The peritoneum was dissected off the lumbar muscles and the ureter located and isolated after some difficulty due to the edema and inflammation which was present. The dissection was continued to the inferior vena cava where there was considerable evidence of periphlebitis. It felt mushy above its bifurcation but the common iliacs could not be examined because of the infection at the site of the previous operation. The vena cava was freed anteriorly and posteriorly but was difficult to separate from the aorta which could be felt but not seen. An aneurysm needle was used to place one No. 3 braided silk ligature which was tied tightly enough to occlude but not strangulate the vena cava. A second ligature was considered but the risk of placing it did not justify its use. One rubber drain was inserted down to the region of the vein and the peritoneum allowed to drop back into place. The wound was closed with No. 0 chromic and black silk to the skin. The patient left the operating room in good condition although his temperature had been 105°F. shortly before operation.

Two days postoperatively there was considerable swelling in the left thigh and scrotum but very little change in the right thigh and leg. There was edema of the back, up to the axilla, which reached its maximum in four days and began to subside so that it had completely disappeared on the seventh day. However,

on March 12th, the patient rather suddenly went into coma from which he did not rouse and died on the night of March 14th. It was believed clinically that the patient had developed either a toxic encephalopathy or a suppurative meningitis, but in view of the ineffectiveness of streptomycin nothing further could be done.

It is interesting to note how many transfusions of whole blood were necessary to maintain the patient's red count above 4 million. In a little over four weeks of his acute illness he received seventeen transfusions of 500 cc. of whole blood as well as other forms of intravenous therapy later in the disease in the form of plasma and amigen.

As to the meningitis which was the immediate cause of death, a question may arise about the use of a spinal anesthetic at the time of the ligation of the inferior vena cava. About three weeks before his death he had three days of headache and stiff neck which cleared up and a spinal tap was not considered justifiable at that time. After his ligation he had five comfortable days with no complaints or symptoms suggestive of meningitis. On his sixth day postoperatively, he was disturbed mentally, had some mild clonic convulsions and soon lapsed into a coma from which he never recovered. It is our belief that the meningitis was a direct result of the septicemia and not connected with the spinal anesthetic.

The patient received one paravertebral block of novocaine on February 12th, the day following the incision of the thigh and the edema was subsiding so rapidly that no more were considered necessary.

The use of heparin was considered but it was believed that his chief problem was one of a septic thrombus and septicemia and that there was little to fear from an embolus.

The organism, *aerobacter cloacae*, is a member of the coliform group com-

monly found in soil and water and indigenous to the intestinal tract. It is often found as a contaminant especially in war wounds but not usually considered a serious pyogenic pathogen. However, while serving in an active theatre overseas we were alarmed on a number of occasions by patients developing a serious toxemia who had a mixed infection which included a heavy contamination of *Bacillus proteus*. This might be explained by the Schwartzman phenomenon. In this case the organisms have been obtained in pure culture from several foci and were not part of a mixed infection.

#### SUMMARY

A case is presented wherein an old retropelvic infection became active with the organism *aerobacter cloacae* and continued to cause a septic iliofemoral thrombophlebitis of the right side. This was temporarily controlled by streptomycin but the organism rapidly developed a resistance to the drug. The septic thrombophlebitis suddenly spread to the left iliofemoral system and the inferior vena cava was ligated in an attempt to control the septicemia. On the sixth postoperative day the patient developed a suppurative meningitis with the same organism and died two days later.

Following ligation of the inferior vena cava there was moderate edema of both thighs, particularly the left and of the back up to the shoulder blades which reached its maximum degree on the third day and subsided to practically normal by the eighth day.

Streptomycin when first administered was effective in inhibiting the growth of *aerobacter cloacae* but rapidly lost its value. *In vitro* tests showed: first day, 0.5 micrograms of streptomycin per cc. of agar inhibited growth; eleventh day, 3.0 micrograms per cc. agar inhibited growth; twenty-fifth day, 40.0 micrograms per cc. agar inhibited growth, and thirty-third day, 500.0 micrograms per cc. agar inhibited growth.

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*A deficient circulation of blood* accompanies some arteriovenous aneurysms; the results include general weakness of the limb, early fatigue on exertion, and perhaps swelling and pain when the limb is dependent—symptoms which resemble those following closure of the main venous channels. A special and noteworthy feature is the speed with which the swelling disappears after elevation of the affected part.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams and Wilkins Company).

# MONTEGGIA FRACTURE

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THE combination of a fracture of the upper end of the ulna with radial head dislocation was first described by Monteggia in 1814. Two cases were reported and the terminology of "Monteggia fracture" has been used quite universally since.

J. S. Speed<sup>8</sup> stated in 1940, that during the previous twelve years thirty-four articles on this subject appeared in the literature, and only two of them were in English. His series of sixty-two is by far the largest on record. In another series of 257 consecutive fractures of the ulna the condition occurred fourteen times, representing about 5 per cent.<sup>2</sup>

The Monteggia fracture may be produced by indirect or direct violence, the basic reason being that the radius and ulna form mutual splints, each bound to the other at the top and bottom by strong ligaments and attached almost throughout by the strong interosseous membrane. The ulna fractures and shortens thereby putting stress and strain on the radial head which dislocates. A dislocated radial head should, therefore, be suspected when there is a fracture of the ulnar shaft four to five inches from the elbow. Neglect of this observation results in a severe disability.<sup>3</sup> The dislocation far out-shadows the fractured ulna in importance.<sup>6</sup> Dislocation of the radial head anteriorly is present in the large percentage of cases (84 per cent). The injury is more often produced by a direct blow on the forearm, and the head of the radius pulls out of the annular ligament, which also ruptures.

The condition occurs in childhood in which better results have been obtained, compared with frequent failures in adults.

Two types of displacement are described: (1) The flexion type, rare, and occurring in 10 to 15 per cent of cases, in which the radial head is dislocated backwards and the ulnar fracture angulation is in the same direction. (2) Extension type, presenting anterior angulation of the ulnar fracture site and a radial head displacement upwards and outwards. This is the common type.

Many complications have resulted, i.e., non-union of the fracture, mal-reduction of the radial head, myositis ossificans, ankylosis of the radial-ulnar joint, and cross union between the radial and ulnar shafts.<sup>10</sup> The angle of the ulnar fracture is usually toward the radius, probably due to pull of the supinator muscle. Dislocation of the radial head may occur in fractures of both bones of the forearm in the upper third.<sup>9</sup>

The management of the Monteggia fracture, extension type, is a difficult mechanical problem. Early operation is recommended, consisting of ulnar plating, radial head reduction and orbicular ligament reconstruction.<sup>1,8</sup> Open reduction is done more often in North American than in the British clinics. The latter claim that repair of the orbicular ligament is unnecessary when accurate reduction of the radial head is done.<sup>7</sup> Manipulation of the forearm with fixation at a 45 degree flexion angle, in supination, is recommended when considering the non-operative management.<sup>4</sup> This maneuver is more successful in children and almost never in adults. Fixation in plaster of paris should extend over a six to eight weeks' period. Operative management is indicated in the non-reducible radial head cases, and excision in the old cases has produced

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FIG. 1. A typical Monteggia fracture, extension type, with marked displacement of the radial head.

fairly good results. However, the radial head should be saved if possible.<sup>9</sup>

There is a strong tendency to the recurrence of the deformity and dislocation of the radial head, and it seems logical to advise primary internal fixation for the fractured ulna with reduction

of the radial head dislocation, and an associated reconstruction or repair of the orbicular ligament.<sup>8</sup> Some authors<sup>10</sup> oppose early reconstruction of the orbicular ligament, stating this can be done two to three months later, after the essential hematoma has absorbed and the tendency



FIG. 2. Lateral view taken three years after reduction, internal fixation of the fractured ulna and replacement of dislocated radial head. There has been some calcification of the reconstructed orbicular ligament. Union is firm at the ulnar fracture site.

FIG. 3. Same as Figure 2; anterior posterior view. Minimal lateral displacement of the radial head is present.

to residual myositis ossificans is reduced. Excision of the radial head in the old cases reduces the tendency to flexion block.<sup>9, 10</sup>

In the flexion type, presenting posterior angulation at the ulnar fracture site and where the radial head is dislocated backwards, reduction is relatively easy by manipulation and traction, followed by plaster of paris fixation in full extension. Operation in this type of case is infrequent. The fixation must be maintained until there is solid ulnar union.<sup>10</sup>

In the great majority of cases, all authors agree that some type of reconstruction surgery should be done, directed toward internal fixation of the fractured ulnar fragments and repair of the ruptured orbicular ligament, or replacement thereof by the use of fascia lata or the deep fascia on the lateral surface of the forearm. The latter technic has the advantage of being able to handle both conditions at the same time through the same incision.<sup>8</sup> With rupture of the orbicular ligament, there is nothing to maintain reduction at the head of the radius. Internal fixation of the ulnar fragments and maintenance of reduction of the radial head are imperative to obtain the maximum function.<sup>1</sup>

#### CASE REPORT

Mr. L. K., a white male, twenty-five years of age, was admitted to Hurley Hospital, Flint, Michigan, November 26, 1940, the victim of an automobile collision. There were multiple injuries involving the left elbow region, the left femur and the left foot. There were many face and scalp lacerations, and the patient was in shock. An immediate examination disclosed fractures of the fourth and fifth toes and an obvious fracture of the left femur. The left elbow showed marked deformity.

The lacerations were sutured and intensive antishock measures were carried out. The fractures were splinted and the patient's general condition did not warrant any further definitive investigation or management. Within a few hours, however, there was a satisfactory response to the preliminary anti-shock meas-

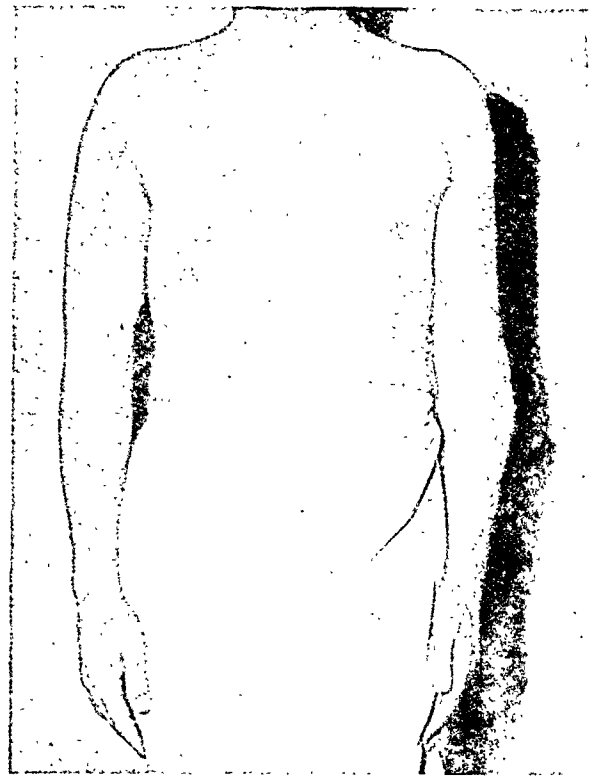


FIG. 4. Photograph five years postoperatively, showing left upper extremity hanging in extension. The forearm is in a neutral position with slight flexion.

ures and x-ray examinations were made of the left elbow, left femur and left foot.

The elbow films showed a fracture at the junction of the upper and second quarter of the ulna with marked overriding and angulation, and a severe upward displacement of the radial head. The left femur showed a long spiral oblique fracture with fragmentation, and marked displacement in the middle third. The fractures in the fourth and fifth toes were insignificant. The left lower extremity was placed in traction, and evaluation of the multiple injuries resulted in a decision to take care of the left elbow bony pathological condition first.

The patient's general condition was considered good enough on November 28th, two days following injury, and he was prepared for an open reconstruction operation on the left elbow. Identification of the ulnar fracture and the dislocated radial head was accomplished through a curved posterior lateral incision over the elbow joint and extending down the forearm for a distance of six inches.<sup>8</sup> The ulnar fracture showed some comminution and the small fragments were removed, inasmuch as they had no muscle periosteal attachments. Reduction was easily accomplished and main-



FIG. 5. Photograph five years postoperatively showing the left upper extremity in abduction; residual elbow flexion deformity of about 20 degrees.



FIG. 6. Photograph showing satisfactory left elbow flexion.

tained by the insertion of a four-screw Vitalium plate on the lateral surface of the ulna. This automatically improved the position of the dislocated radial head, and with the aid of digital pressure a complete reduction was accomplished. However, the slightest movement in any direction produced a redislocation. The orbicular ligament was completely evulsed. A strip of the deep fascia from the lateral surface of the forearm three to four inches in length and one-quarter inch in width was liberated, leaving its base intact at approximately the level of the radial neck. The free end was then threaded around the radial neck and attached to the fixed basilar portion, thus producing a sling, so to speak, as well as a fixation agent against the tendency to recurrent dislocation.<sup>8</sup> A satisfactory retention was secured by this means. The wound was irrigated with saline solution and closed in layers with chromic catgut for the subcutaneous tissue, and cotton for the skin. The left upper extremity was immobilized in a plaster of paris dressing extending from the axilla to the knuckle line, with the forearm at right angles and in supination.

A postoperative film showed satisfactory position at the ulnar fracture site and a complete reduction of the radial head dislocation. Progress films taken weekly showed a maintenance of these findings. The plaster dressing was removed at eight weeks and a check film showed osteogenesis in progress at the ulnar fracture site and a maintenance of the radial head reduction. Clinical examination showed a normal contour at the elbow with a minimal degree of active and passive supination and pronation, and a flexion arc of about thirty-five degrees. (It is to be noted that in the meantime, and shortly after the elbow reconstruction, open reduction, fracture assembly and internal fixation was done for the femoral fracture.) A lighter plaster of paris dressing was again applied to the left upper extremity as a precautionary measure, and this remained in place for a month. Following removal physiotherapy measures were instituted under a competent physiotherapist. There was progressive improvement in all movements. The wound had healed by first intention.

Further management of this patient then was concentrated upon the femoral fracture, and

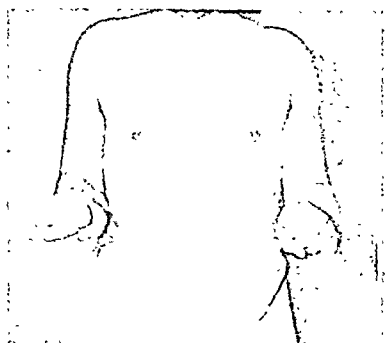


FIG. 7. Photograph showing minimal restriction of pronation of the left forearm.

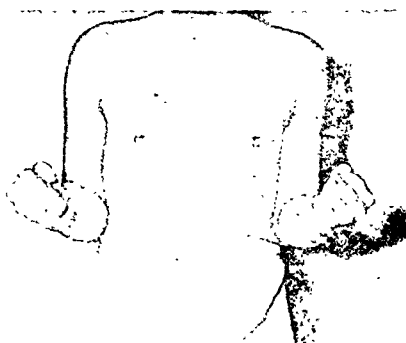


FIG. 8. Photograph showing minimal restriction of supination of the left forearm.

coincidentally the left elbow disabilities gradually improved. At five months there was almost complete supination and pronation, and flexion within ten to fifteen degrees of normal, with about the same for extension.

Clinical examination of the patient made March, 1946, showed almost complete flexion of the left forearm, minimal restriction of supination and pronation, and an extension limitation of about ten degrees. The patient was conducting his occupation as a skilled mechanic.

#### COMMENTS

In this case the radial head dislocation was severe and the destroyed orbicular ligament was replaced by the use of a segment of the pronator fascia, of selected length and width. This followed internal fixation of the ulnar fragments. The satisfactory result obtained indicates the proper selection of early operative management.

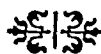
Two identical cases in adults have since been handled the same way with comparatively good results. Two cases in children, one aged six and one aged eight, have been satisfactorily handled by manipulation, radial head reduction, and plaster of paris fixation with the forearm supinated and in fifty degrees of flexion. Both cases gave satisfactory results. In all five cases there was a failure to restore full complete function.

In a recent case of long standing, ten years, the radial head was excised. The indications for excision were localized pain and motor disturbances associated with the radial nerve. The anteriorly displaced radial head exhibited a prominent tumor mass and there was some restriction of supination and pronation. Forearm flexion and extension were off about 10 degrees. Removal was done through an anterior incision and an excellent result followed.

Osteogenesis at an ulnar fracture site is notoriously slow, and indicates protection for a long time. In young children the orbicular ligament seems to slip back over the radial head with greater ease. The impression obtained is that following a Monteggia fracture complete restoration of normal function is a rarity. Satisfactory function, however, may be obtained when early management is possible, carefully selected and painstakingly done. This injury presents a major surgical problem to the fracture surgeon.

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# SPONTANEOUS SALPINGO-COLIC FISTULA COMPLICATING PYOSALPINX\*

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**A**CUTE pyosalpinx is generally considered to be a self-limited disease which is best treated in the acute phase by rest, the administration of chemotherapeutic agents and the application of various forms of heat. The usual clinical course is one of gradual subsidence of inflammation, and operative interference is elected for residuals or late complications. Serious complications do, however, occur in the acute phase. The most common of these is the extension of the inflammatory process locally into the peritoneal cavity. The rupture of an empyema of a tube into the peritoneal cavity to form an abscess is not an uncommon complication. These abscesses are most often found in the cul-de-sac or depths of the pelvis, and therefore in direct relationship with the rectosigmoid, into which they often drain. Resolution and healing are thus made possible. The narrow and devious channel by which the abscess drains into the rectum, being lined with inflammatory tissue, ultimately heals spontaneously. Should there be established, however, a direct communication between the wall of the tube and a neighboring viscus, spontaneous closure is much less likely to occur. The literature is replete with reports of chronic fistulas established between a Fallopian tube and the vagina, uterus, bladder, rectum and even the skin surface.

A review of the recent literature fails to reveal the report of any cases with an intestinal fistula above the rectum. It was therefore thought to be of interest and value to report the following case and describe its management.

## CASE REPORT

A twenty-nine-year old married, colored WAC entered the Halloran General Hospital June 8, 1944, complaining of lower abdominal cramp-like pain and diarrhea of five days' duration, generalized abdominal discomfort between cramps, and persistent low back pain of a type that she had always experienced during menstruation. She was having six to eight loose watery stools daily, and had had a severe chill on the day following the onset of her present episode. She had been febrile for the past two days. Catamenia had started at eleven years, occurring every twenty-eight days, lasting at first only three days, but gradually increasing to five to eight days in the recent past. Her last menstrual period had started on May 25, 1944, lasting eight days. Her present illness began, therefore, one day following the cessation of menstruation. A moderate purulent vaginal discharge had been present for about a week before her admission to the hospital. She denied any aberration of her catamenia. Anorexia and loss of weight had been noted for approximately one month.

Examination revealed an acute and chronically ill, young negress some thirty-five pounds below normal weight. Physical findings were confined to the abdomen and pelvis. There was a large tender mass deep in the left lower quadrant. There was fullness but no definite mass in the right lower quadrant. The cervix was smooth but red and there was a thin yellowish discharge from the os. On pelvic examination, the viscera were found to be "frozen" with a large tender mass in the left adnexal region, a large boggy uterus and thickening of the right adnexa. It was believed that she had a tubo-ovarian abscess. The red cell count was 4.01 million; white cell count 14,450. A course of intra muscular penicillin was administered with some improvement, her fever gradually subsiding from 103°F. to 100°F. On

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FIG. 1. Roentgenogram of barium enema demonstrating the fistula between sigmoid and left Fallopian tube.

proctoscopic examination, an intensely red, indurated, canalized segment 5 cm. long was visualized extending proximally from a point 17 cm. above the anus. There was a large amount of pus in the lumen of the canal, but neither ulceration nor fistulous orifice could be seen.

On July 19, 1944, a barium enema demonstrated a cavity 4 by 5 cm. lying anterior to the sigmoid, and communicating with it through a narrow channel. (Fig. 1.)

The patient continued to have three to five loose stools daily, and an evening rise in temperature to 100°F. Pelvic examination now revealed a discrete tubo-ovarian mass in each adnexal region, larger on the left. Stools contained neither blood, ova nor parasites. The Frei test was negative. It was now believed that the patient had a bilateral pyosalpinx, and that the left had perforated into the sigmoid. A series of Elliott treatments was administered from August 26th to October 20, 1944. During this time, there was gradual improvement in general well being and some gain in weight. She was now having two stools daily. An improvement was also noted on pelvic examination. The uterus was about normal in size, the right adnexal mass was smaller, moveable and non-tender; the left adnexal mass was also smaller, spindle-shaped and non-tender.

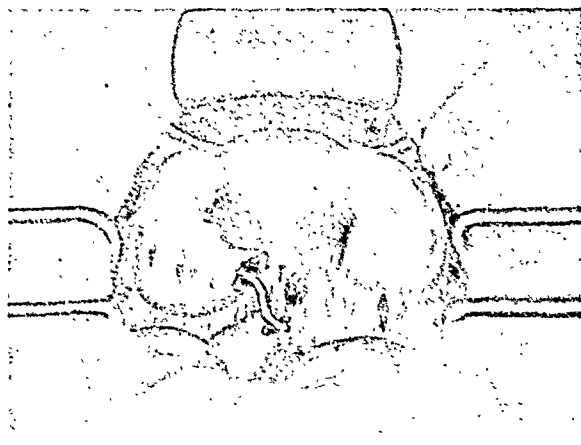


FIG. 2. Drawing showing the ostium of the left tube after separation from the fistulous orifice in the sigmoid. A catheter has been passed into each orifice.

A pelvic operation was performed on December 7, 1944. The uterus was normal. There was an inflammatory mass in each adnexal region incorporating tube and ovary. Loops of small bowel were extensively adherent to these masses. After separating them, it was obvious that the sigmoid was firmly adherent to the left adnexal mass in an area representing the distal end of the tube and that the fistula coursed through this adhesion. According to the preoperative plan, no further procedure was done in the pelvis, but a double-barrelled spur type of colostomy was established through a small upper rectus incision. The colostomy was opened in forty-eight hours. Convalescence was essentially uneventful. The isolated distal segment was irrigated daily. Proctoscopic examination on January 25, 1945, revealed marked improvement in the previously inflamed segment, and the internal orifice of the fistula was clearly visualized.

Because of the presence of gram-positive cocci and gram-negative rods in the cultures of rectal pus, the patient was prepared for further surgery with oral sulfadiazine and intramuscular penicillin. On February 16, 1945, a second operation was performed. The fistula, as previously determined, was found communicating between the anterior surface of the lower sigmoid and the ostium of the left tube. (Fig. 2.) The fistula admitted the tip of the finger. The mucosa of the tube was directly continuous with the mucosa of the bowel, exactly as in a surgical anastomosis, without intervening scar tissue. Because of this unusual pathological accident, it is doubtful that spontaneous closure would ever have occurred.

The fistulous orifice in the sigmoid was closed with two purse-string sutures. The left tubo-ovarian mass was ablated. Postoperatively the convalescence was quite uneventful, except for slight superficial separation of the abdominal wound margins. Pathological examination later revealed a non-specific inflammatory disease of the tube. The isolated distal segment was again frequently irrigated. The purulent discharge decreased very gradually and finally became mucoid. On May 5, 1945, a proctoscopic examination showed a rather normal appearance of the previously inflamed segment of sigmoid. A small polypoid irregularity of the mucous membrane alone remained to indicate the original site of the orifice. The patient's general condition had improved greatly. Accordingly, the colostomy spur was reduced by a spur-crushing clamp, and on June 6, 1945, the colostomy was closed extraperitoneally. Convalescence from this procedure was entirely uneventful. Normal and asymptomatic bowel habits were restored. On October 5, 1945, an

extraperitoneal repair of a fascial defect of her lower abdominal wound was done, and she was discharged to duty in November, 1945.

At the time of her discharge, there was still a moderate thickening of her right adnexa, but her menstrual function was quite normal. Her bowel function continued to be normal and she had regained her strength and weight.

#### SUMMARY

1. A case is presented of acute bilateral pyosalpinx which spontaneously established a chronic fistulous communication between the left Fallopian tube and the sigmoid colon.

2. Photographs of the roentgenological films demonstrating the fistula are reproduced.

3. The operative management for the cure of this anomalous accident has been described.



# LIGATION OF THE INFERIOR VENA CAVA

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**L**IGATION of the inferior vena cava is a major surgical procedure, the value of which has not been ascertained fully. It is a subject of considerable clinical interest with a history of abandonment and revival of the operation. Recently, supportive evidence in favor of ligation of the inferior vena cava has been presented, especially for thrombophlebitis of the pelvic veins and for bilateral venous thrombosis involving the femoral and iliac veins.<sup>1,2,3,4</sup> The following case report deal with the latter condition.

## CASE REPORT

E. B. Twenty-two years of age, was admitted to the hospital because of pain in his chest and in his right leg. The present illness dated back six months at which time the patient was operated on for acute appendicitis. On the seventh postoperative day he suddenly developed chills, fever and pain in his chest. For a period of four days thereafter there was a marked elevation of temperature ranging up to 104°F., cyanosis and leukocytosis. At that time, x-rays of his chest were positive for multiple areas of infiltration suggestive of pulmonary infarction. On the eighteenth postoperative day the patient developed severe pain and swelling of the left leg below the knee with gross clinical signs of involvement of the superficial veins. Within twelve days the right leg was similarly involved but the swelling did not become as marked as in the other leg. Therapy consisted first of sulfadiazine and oxygen inhalations. Later treatment was changed to penicillin and heparin. After three months hospitalization the above described signs and symptoms subsided and the patient was discharged as recovered.

Three months later, there was a sudden onset of pain again in his right lower chest associated with chills and fever. This was followed in quick succession by tenderness and swelling of the right thigh and leg. This recurrence resulted in a second hospital admission

where, for a period of ten days, treatment with heparin and sulfonamides was repeated but with no significant improvement in his condition. He was then transferred to Ashburn General Hospital for further treatment.

Physical examination revealed the following: Fine râles were audible over the right lower lung with decreased resonance over that area. The postoperative McBurney incision was well healed. No masses were palpable on abdominal examination. There was marked tenderness to light pressure over the inguinal region; especially over the site of the femoral vessels. The right leg was held in acute flexion. According to the patient, this position only provided relief from pain. Any movement of the limb by the examiner seemed to be painful particularly that of extension. There was a visible superficial thrombophlebitis over the mesial aspect of the right leg. The femoral vein was tender to touch and compression. Homan's sign (the dorsiflexion test) was positive bilaterally, but was more marked on the right. On percussion over the lower back diffuse tenderness was elicited.

After consultation between the medical and surgical departments, it was agreed to ligate the inferior vena cava. The operative incision was that employed for right lumbar sympathectomy. The vena cava was exposed retroperitoneally and freed from its posterior attachment to the spine for a distance of about 2 inches. Marked enlargement of the lumbar veins was noted at the time of operation. These veins appeared very much larger than usual, the comparison being based on the author's experience with lumbar veins when performing right lumbar sympathectomy for other peripheral vascular disorders. On palpation, the common iliac veins were thick, pipe-like tubes. Proximal to the bifurcation, the vena cava was soft and easily compressible. That portion of the vena cava just cephalad of the bifurcation was constricted by slowly tightening a hernial tape about it and then ligated with the double strands of No. 4 chromic catgut at 3 points  $\frac{1}{2}$  inch apart. Just

prior to the ligation, the perivenous nerve fibers surrounding the vena cava were stripped off the vein and cut. In addition the lumbar sympathetic chain was interrupted at L<sub>3</sub> and the ganglion removed.

Immediately after operation the patient felt completely relieved of pain in the lower abdomen and was able to move his right limb freely. On the sixth postoperative day, improvement in the chest symptoms was noted. On the nineteenth postoperative day, there was no longer impairment of resonance or diminution of breath sounds over the right lower chest and the patient was allowed out of bed. Swelling of the extremities was present during the first few days of ambulation, but this finally disappeared after a short period with elastic bandages. Heparin was not used postoperatively. Penicillin was given during the acute postoperative phase.

A variety of laboratory tests were made. An early electrocardiogram revealed a right axis deviation, moderately severe, with a negative T<sub>4</sub> suggestive of pulmonary embolism. On the eighteenth postoperative day the electrocardiogram showed that T<sub>4</sub> returned to upright, but the right axis deviation persisted. On one occasion shortly after the operation the venous pressure was 52 cm. of water. The circulation time of the lower extremities done by the injection of alpha lobelin and calcium gluconate gave no sharp end point. The circulation time by means of the injection of fluorescein 5 per cent in sodium bicarbonate solution caused a visible change in the lips under ultraviolet in 135 seconds. However, the latter reading may have been erroneous due to inexperience with this method. Dermotherm readings showed the right foot and its toes to be 2-6 degrees warmer than the left. Diodrast venographic studies were made of the right and left extremities and the pelvis. The veins of both lower limbs showed such phlebotic characteristics as "moth-eaten appearance and a hairpin shaped configuration" of the veins. In addition, the venograms showed that the blood tended to go through the greater saphenous system of the thigh, apparently indicative of deep venous obstruction or spasm. At the pelvic level considerable dye passed medially to the contralateral side and proceeded upward. The iliac veins and the inferior vena cava distal to the ligation were not visualized. Blood cultures were sterile. Postoperatively the hematocrit

cell volume showed no significant alteration in the cell plasma volume relationship attributable to ligation of a main source of blood supply. The blood sedimentation rates subsided to normal as the patient's symptoms improved.

The indications for operation in this case were bilateral thrombosis of the femoral and iliac veins with severe pulmonary infarction on at least two occasions. Although heparin might have been beneficial to the extent of inhibiting the propagation of emboli, after discontinuance of the drug embolization recurred nevertheless. In this case, even before the operation was performed, collateral circulation was in the process of development as evidenced by the size of the lumbar veins. The rationale of sympathectomy was to open all collateral venous channels for the return flow of blood and to interrupt the pain conduction pathways via the sympathetic tracts. This was accomplished by perivenous sympathectomy and ganglionectomy of the right sympathetic trunk at L<sub>3</sub>. Its effectivity was made evident by the striking subsidence of pain. As to the value of the operation, it may be regarded in this particular case either as a lifesaving procedure if not at least as a method for reducing the morbidity of pulmonary infarction and prolonged hospitalization. Follow-up, seven months after the operation showed the patient to be fully active with no recurrence of chest pain. On one occasion tenderness and redness of a superficial vein of the thigh developed but this subsided within twenty-four hours.

Ligation of the inferior vena cava may be considered as a beneficial operation with a sound clinical and anatomical basis. It seems to be specially indicated when chemotherapy is inadequate and a diagnosis of pelvic vein thrombophlebitis or bilateral phlebothrombosis of the lower extremities has been made. By ligation of the vein the circulation through the involved venous pathway is slowed and biochemical antibodies in increasing concentrations are enabled to act upon the

thrombotic focus. Anatomical analysis and venographic studies of collateral venous channels have shown that the return flow of blood from the lower extremities to the heart is adequately provided for when the inferior vena cava is ligated in the vicinity of its bifurcation. The value of surgical or chemical sympathectomy in conjunction with ligation has been noted by Collins et al.<sup>2</sup> in their clinical reports.

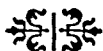
#### SUMMARY

A case record of recurring pulmonary embolization treated by ligation of the

inferior vena cava, ganglionectomy and perivenous sympathectomy is reported.

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CIRROID aneurism is a rare condition, but of importance owing to difficulty in treatment. It is due to dilatation of the arteries, which open more or less directly into venous spaces. Capillary naevi are sometimes seen in the overlying skin.

From "A Short Practice of Surgery" by Hamilton Bailey and R. J. McNeill Love (H. K. Lewis & Co., Ltd).

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# New Instruments

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## NEW TYPE OF FASTENER FOR JOINT SEPARATIONS AND OBLIQUE FRACTURES

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THE Dzus spiral cam fastener is a simple, self-locking device used to facilitate quick assembly or disassembly of detachable or hinged parts. During World War II it was the most widely used self-locking device on military aircraft, ordnance, signal corps and naval equipment.

During the past year this fastener has been adapted for use in certain types of fractures and joint or mortise separations. This preliminary report is written to record the advantages, the mode of application and the early postoperative results that have been observed in a small series of cases. It is understood that the end results cannot be determined over the short period of time since the initial application of the first fasteners in September, 1945.

The assembly consists of a tapped spiral cam stud and clip as illustrated in Figure 1A. The shaft of the stud is made up in varying lengths of  $\frac{1}{4}$  inch gradation. The stud itself is divided into two parts by means of a take-up screw in its distal end. The amount of take-up is  $\frac{7}{16}$  inch allowing for any gradation that may be needed between the  $\frac{1}{4}$  inch lengths. The head of the stud does not have the conventional slot groove that so often strips when any amount of pressure is exerted with the screwdriver. In its place is a hexagonal socket (Fig. 1A) for insertion of the hexagonal screwdriver illustrated in Figure 1B. The distal end of the stud is uniform in length in all of the assemblies.

It measures  $\frac{8}{16}$  inch and its distal end forms the spiral cam fastener that engages the nut on the opposite side of the bone. The clip is an oval stamped piece with two prongs, one at either end for gripping the bone. The prongs prevent rotation and unlocking.

The cam stud and clips are made of 316 type stainless steel rather than Vitalium insofar as the parts are machined and not cast. Under test, the assembly is capable of standing up under more than 250 pounds of stress as tested by laboratory methods.

The immediate advantage of internal fixation with this device is the short period of morbidity and early use of the injured part due to firm fixation of separated or fractured fragments. In all of the cases reported there was no need for plaster immobilization. Motion in the proximal and distal joints was instituted on the first postoperative day with the result that no joint motion was lost as would have been the case had accessory splinting been required. The average length of bed rest required postoperatively was under three days. The period of three days was necessary only to overcome the usual postoperative morbidity due to immediate postoperative pain and temperature. It was apparent that the pain was less than the average open reduction would entail.

The second advantage is the fact that the fixation is more stable insofar as metal grasps metal rather than bone.

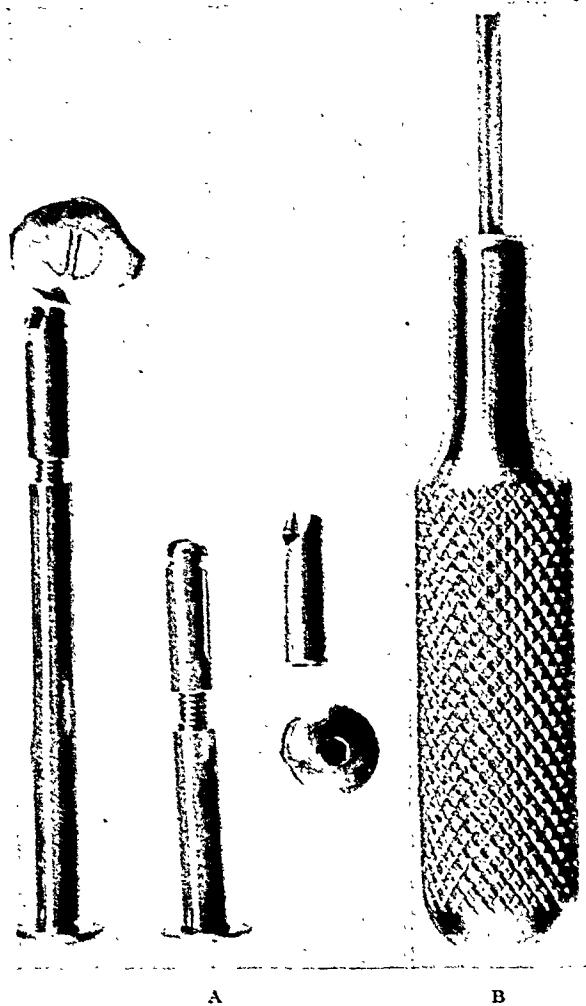


FIG. 1. A, illustrating fastener assembly and hexagonal socket in screw; B, hexagonal type screw driver.

The common bone screw depends on a metal thread holding in a bed of cortical bone, adequate for fixation when aided by external splinting but inadequate for the stress of body weight.

The ability of the oval clip part to tilt without affecting the locking mechanism is a distinct advantage when it comes to fitting curved or sloped contours of bone. (Figs. 2 and 3B.)

The operative technic used by the author was not extraordinary in any way. In the case of ankle mortise fixations the foot was held in the right angle position while the fastener was tightened. The amount of pressure exerted in tightening the screw was no more than the operator would have applied with the ordinary bone screw. It is imperative to have all sizes on hand at the time of surgery rather than to depend on accurate measure-

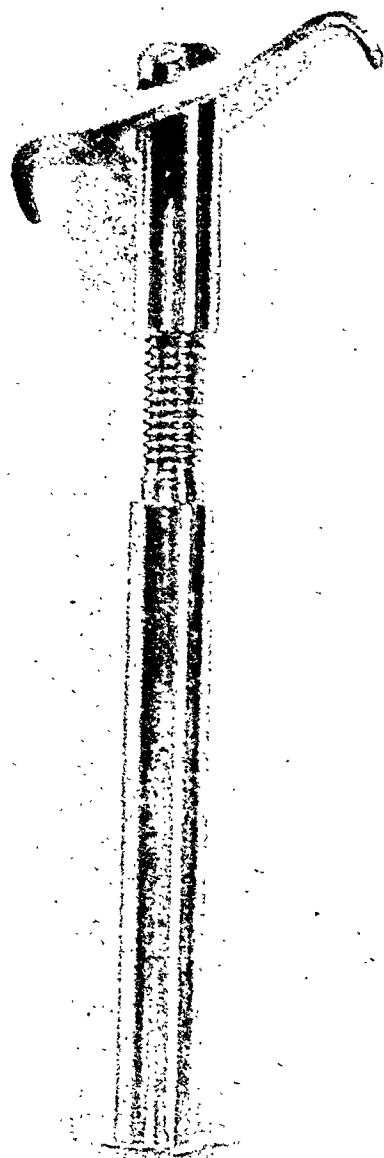


FIG. 2. Illustrating the oval clip tilted without affecting the locking mechanism.

ment roentgenographically as evidenced in Figures 5A and B, where the screw was considerably shorter than would appear necessary from an anteroposterior view of the tibia. The bit employed fits the ordinary Jacob's chuck and is calibrated to the exact size of the fastener's diameter. The oval clip part of the assembly is furnished in two diameters,  $\frac{5}{8}$  inch and  $\frac{9}{8}$  inch. In each of the cases operated upon, the fastener was extended to its full length prior to insertion allowing for easy locking of the cam and allowing for maximum take-up. Countersinking of either the head or of the oval clip is not advised as the full thickness of cortical bone is depended upon for support.





FIG. 3. A, illustrating fracture of lateral malleolus and slight mortise spread; B, illustrating reduction of mortise separation (Fig. 5B) and tilting of oval clip. Drill hole placed high in fibula to avoid fracture line.

In the series of cases reported there were four ankle mortise separations, one with a concomitant fracture of the external malleolus and another with a longitudinal fracture through the internal malleolus. In all four separations the incision of entry was no longer than 1 inch. The position of the incision of exit was determined by the point of exit of the bit after it had passed through both fibula and tibia. The second incision was  $1\frac{1}{2}$  inches

long to facilitate the placing of the oval clip. Surgery was carried on subperiosteally and the periosteum was drawn taut over both ends of the assembly. A tourniquet was used and a soft pressure dressing was applied in the lower extremity.

Two of these patients were up and about bearing weight without the aid of cane or crutches in four days. The other two were up on the third postoperative day and wore canes for a period of twenty-



FIG. 4. A, mortise separation with longitudinal fracture through medial malleolus; B, postoperative reduction of mortise spread. This fastener was inserted in the author's absence. It is high in its position and should include the fracture at a lower level. The postoperative convalescence and the early return of function with asymptomatic weight bearing at the end of four days would seem to indicate that the operator was correct in placing the fastener assembly above the fracture line.

four hours, after which they walked unaided by any external support. It was surprising to find that neither of the patients who had sustained fractures of their malleoli complained of pain in or about the ankle. The patient who had sustained a fracture of the external malleolus (Figs. 3A and B) was back at work on the eighth postoperative day. His job entailed standing and walking for the greater part of his eight-hour day. On return for a check up one month later his only complaint was a dependent swelling of the ankle that came on after prolonged standing and that subsided after a night's rest. The patient who had sustained a fracture of the medial malleolus (Figs. 4A and B) was actively engaged in basketball and other gymnasium sports on the eighth postoperative day. This last patient was well over 6 feet tall and weighed over more than 200 pounds. The two separations uncomplicated by fracture were engaged in their usual activities in less than ten days. The limp that is commonly seen as the end result of prolonged immobilization and loss of normal range of dorsiflexion at the ankle joint was conspicuous by its absence in all four of these individuals.

The fifth patient sustained an oblique fracture through the lateral tibial table. (Figs. 5A and B.) A fastener was inserted through bilateral incisions. The fracture was visualized in the incision and was seen to reduce itself as the take-up screw in the shaft was tightened. On the fourth postoperative day this patient was able to put his knee joint through a complete range of flexion and extension. He was bearing weight with the aid of crutches on the fifth day and was walking without any external support in ten days.

Two patients with acromioclavicular separation were operated upon. (Figs. 6A and B.) Both cases were chronic separations for which conservative methods of reduction had failed. The fastener was inserted in a drill hole that passed through the outer end of the clavicle and

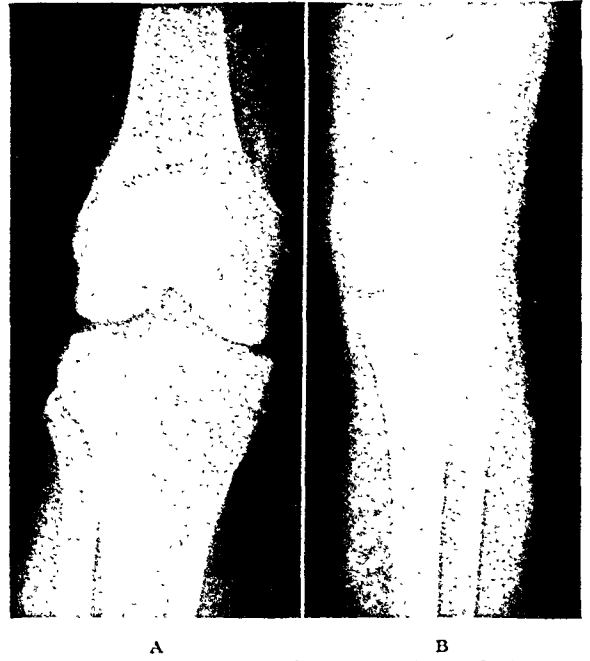


FIG. 5. A, illustrates fracture through lateral tibial table. At operation fracture was considerably more extensive than it appears in roentgenograph; B, postoperative internal fixation of fracture. At operation fracture was seen to reduce itself as fastener was tightened.

through the coracoid process. The two-pronged oval clip was placed on the under surface of the coracoid with its prongs placed upwards so that they might grip the under surface of the coracoid process. The fasteners were tightened by means of the take-up screw until the clavicle was brought into normal relationship with the acromion. Postoperatively these patients were up and about in two days. There was considerable limitation of motion and a minimum of pain. Abduction of the upper extremity was limited to 70 degrees. Constant use of the shoulder girdle with its attendant rotary motion was followed in a period of five weeks by a disengaging or unscrewing of the take-up part of the bolt in its shaft. The fasteners were removed and it was observed at the time of the secondary operations that the desired acromioclavicular reduction had affected itself. There was a firm fibrous tissue encapsulation of the acromioclavicular joint that scar tissue had formed secondary to the operative trauma at the time of the installation of the fastener. No further fixation was necessary following

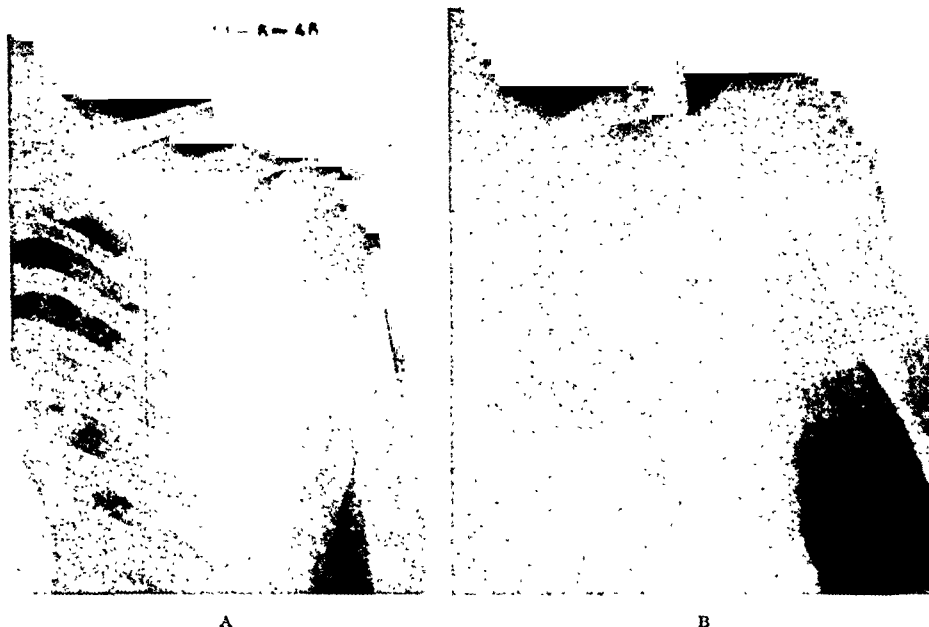


FIG. 6. A, illustrated chronic acromioclavicular separation; B, postoperative x-ray following the insertion of fastener through clavicle and coracoid process.

removal of the stud and clip. The postoperative increase in range of abduction was almost immediately increased.

#### SUMMARY

A preliminary report on a surgical adaptation of the Dzus fastener, widely used in industry and military construction, is furnished.

It appears at this early stage of its use that it is an adequate means of fixation for certain types of oblique fractures and for separation of the ankle mortise with or without complicating fractures of the malleoli.

It has the distinct advantage of firm fixation with a minimum of morbidity and shortening of convalescence due to

the lack of need for external fixation. It allows for early mobility of neighboring joints, thus preventing the disuse atrophy and limp that are associated with prolonged immobilization.

In acromioclavicular separation it is not a permanent installation but probably will prove an efficient method of maintaining satisfactory immobilization of the joint and reduction of the deformity. Operative trauma with its resultant scar and fibrous tissue formation at the acromioclavicular joint is adequate to maintain the normal acromioclavicular relationship after the fastener has been removed.

The author wishes to express sincere gratitude to Mr. William Dzus for his many helpful suggestions and kind cooperation in developing this fastener.

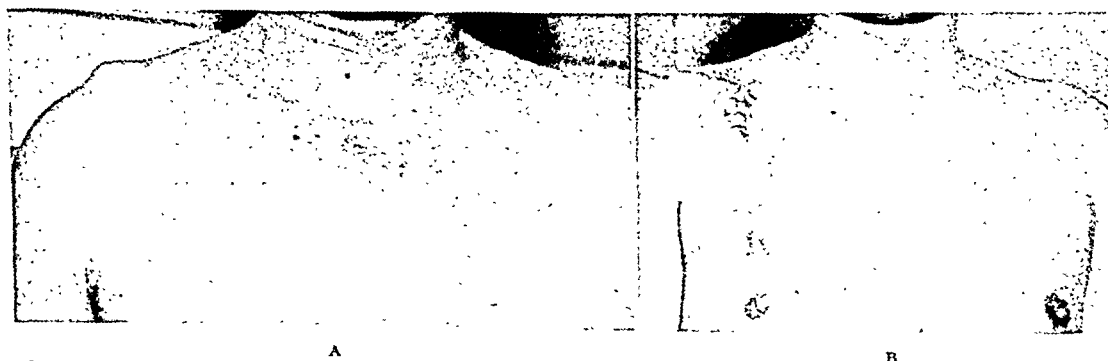


FIG. 7. A, preoperative deformity of separated acromioclavicular joint; B, illustrates correction of deformity and healing incision.

# APPARATUS FOR REFRIGERATION ANESTHESIA\*

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SÃO PAULO, BRAZIL

TO simplify the refrigeration of the extremities for conservative or anesthetic purposes, we suggested an apparatus which prevent it from falling sideways. The whole apparatus is metallic, chromed and can easily be sterilized.

FIG. 1.

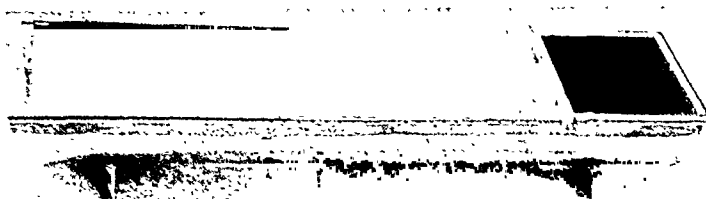


FIG. 2.

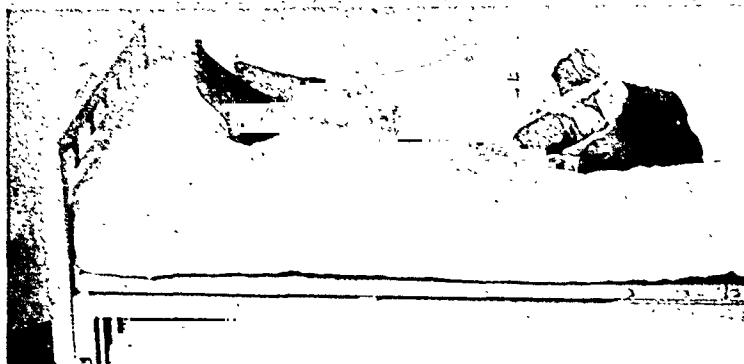


FIG. 1. Apparatus for refrigeration.

FIG. 2. Ice bags are placed at the spot chosen for the tourniquet thirty minutes before.

paratus in which the limb or limb segment is placed for refrigeration. It consists essentially of a hollow half cylinder 105 cm. by 22 cm. in diameter.

One of the ends is open, about 3 cm. to avoid the melting ice from wetting the patient or bed sheets. The other end is closed. A collector tube at the bottom of the hemicylinder and in communication with has many perforations to drain the water of the melting ice. One end of this tube is closed and the other one is opened and curved. At the curved end a rubber tube is attached that connects the apparatus with a bucket placed on the floor near the bed. The edges of the hemi-cylinder contains perforations every 2 cm. A mobile wall to save ice is fixed to the edges of the apparatus by screws. There are two transversal bars at the bottom of the apparatus

## TECHNIC OF REFRIGERATION

We put the limb or limb segment to be refrigerated into the apparatus so that the spot in which the tourniquet will be placed is at least 15 cm. from the open end of the apparatus. Then we place the mobile wall near the distal extremity of the limb. After applying the torniquet at the ideal spot chosen, we spread the ice evenly on the limb to about 10 cm. above the tourniquet and cover the whole thing with a sheet. The ice must be replaced as it melts. It is unnecessary to raise the bedstead because even in the horizontal position, the water from the melting ice does not wet the patient or the sheets.

## ADVANTAGES

This apparatus gives a relative immobilization of the extremity to be re-

\* From the Professor Godoy Moreirá's Clinic at the Hospital of the Medical School of the University of São Paulo Brazil.

FIG. 3.



FIG. 4.



FIG. 5.

FIG. 3. Skin analgesia is obtained by ice bags; a tubular tourniquet is then placed and maintained by surgical clamps.

FIG. 4. The limb is placed in the apparatus, the mobile wall is adjusted to the right place so that the tourniquet is 15 cm. from the open end.

FIG. 5. The limb is covered with triturated ice to approximately 10 cm. above the tourniquet. The tiptoes remain uncovered for the blood supply and sensibility tests.

FIG. 6.

FIG. 6. The whole thing is covered with a sheet to avoid quick melting of the ice.

frigerated, and this immobilization avoids the shock before the limb is entirely refrigerated.

It permits the refrigeration of the extremities and prevents wetting of the patient or bed sheets.

It permits a more even distribution of the ice around the limb or limb segment to be refrigerated.

It permits the control of the ice melting and its easy replacement.

It makes watching of the limb and its sensibility test easy during the refrigeration stage.

It permits the transport of the patient to the operating room without wetting the floor by the melting ice just by turning upwards the distal extremity of the rubber tube of the outlet on the apparatus itself.

Ease in cleansing and sterilization is provided.

Ice is saved, for the mobile wall limits the zone to be refrigerated.

It makes possible refrigeration of the lower as well as of the upper limbs, and the refrigeration can be carried out without raising the bedstead.

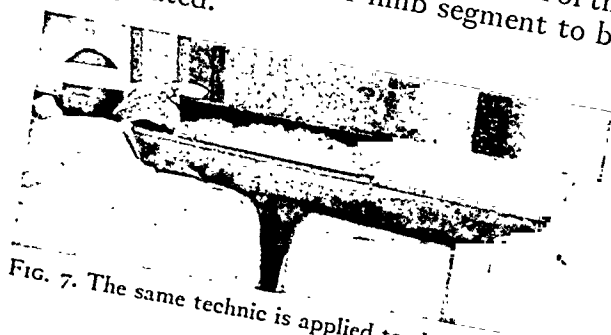


FIG. 7. The same technic is applied to the upper limb.

# NEW LIGATION KNIFE FACILITATING SUBCUTANEOUS LIGATION OF VARICOSE VEINS

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**M**ULTIPLE percutaneous ligations and discissions of varicose veins, supplementing high ligation of the great saphenous vein at the fossa ovalis, appears to reduce the high incidence of recurrences greatly. This "closed" procedure, combined with "open," multiple, partial or total phlebectomies, is superior to the method of retrograde injection of sclerosing agents in relation to postoperative morbidity and recidivation. Furthermore it is a timesaving operation, can be performed easily and contributes to render the patient ambulatory who has had surgical intervention, a prerequisite to avoid embolic disaster.<sup>9</sup>

The retrograde injection of sclerosing agents should be abandoned as it is followed by severe reactions in a high percentage of cases, especially when sodium morrhuate or its equivalents are used.<sup>1</sup>

In cases of acute migrating phlebitis where sclerotherapy is absolutely contraindicated, percutaneous ligations of unaffected varicose above the phlebotic sectors combined with high ligation of the great saphenous vein, operative removal of the thrombi and application of supportive bandages, keep the patient ambulatory, and greatly shorten and ameliorate the morbidity.

Subcutaneous ligations of varicose veins were done occasionally in the pre-aseptic period. The results, however, were discouraging. In 1922 R. Klapp<sup>5</sup> rediscovered this method, and B. M. A. Goldstone<sup>4</sup> advocated it 1943.

A. K. Monro,<sup>8</sup> criticising Goldstone's publication, considers subcutaneous ligation obsolete and antiquated, and wishes to see it laid to rest. In the beginning the writer was inclined to support Dr. Monro's objections, but after a period of intensive investigation and trials he arrived at

the conclusion that subcutaneous ligation used as a subordinated procedure, in combination with high ligation, multiple phlebectomies and discissions, followed by sclerotherapy, has its distinctive merits and deserves decidedly more earnest and liberal consideration than A. K. Monro is willing to give.

Klapp and Goldstone<sup>4,5</sup> used curved and straight surgical needles. Their method, however, produced crowding of the ligated tissue underneath the skin with resulting retraction of the skin perforations and bulging of the skin between these openings.

In order to avoid this disadvantage the writer uses a ligation knife\* instead of a needle. It consists of handle, middlepiece and blade. (Fig. 1.) The blade has a knife-like cutting edge at its total circumference with an eye at its distal end to carry the ligation suture. It is slightly curved in the vertical plane.

*Technic.* For local anesthesia 5 cc. of 1 per cent novocaine is used. From an intradermal wheal 1 cm. lateral from the vein the skin above the vessel is infiltrated towards the contralateral side. The deep perivenous tissue is infiltrated by V-shaped injection, inserting the needle through the already anesthetized skin-segment.

*First Step.* It is made sure that the varix can either be seen or palpated before starting the operation. (Fig. 2a.)

Through a stab incision lateral to the vein, the ligation knife is carefully pushed towards the opposite side in close contact with the skin, moving the blade freely in the horizontal plane in order to create a wide canal for the suture. The contralateral side reached, the knife is pierced through the skin and catgut, silk or cotton

\* The knife is manufactured by the Clay-Adams Co., Inc., New York, N.Y., according to the specifications of the writer.

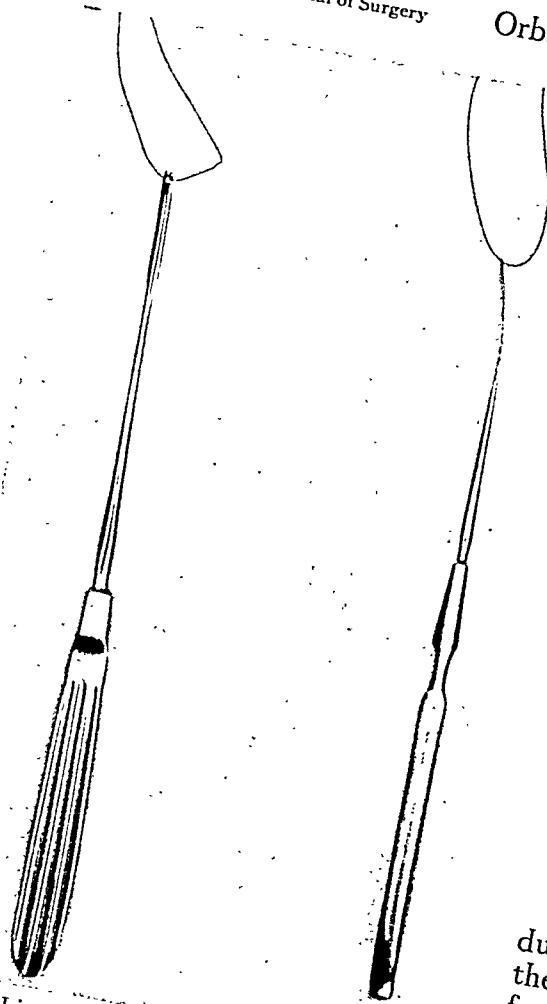


FIG. 1. Ligation knife (front and profile views).

No. 0 or No. 00 is threaded through the eye. In cases where the connection between the skin and vein wall is very firm, separation will be facilitated by using a small narrow blade before introduction of the ligation knife.

**Second Step.** The instrument together with one end of the suture is withdrawn through the primary opening. The thread runs now from the primary opening between skin and vein through the second contralateral skin perforation. (Fig. 2b.)

**Third Step.** The instrument is reintroduced into the primary stab incision almost vertical to the skin and worked along underneath the vein, moving the blade up and down in order to create a posterior canal for the ligation. (Fig. 2c.) It is advised to palpate the vein with the index finger of the left hand during this procedure,

to make sure to have the vein above the blade. As soon as the blade emerges from the secondary opening, the suture is threaded through the eye of the knife. At the end of this step the vein rides over the ligation knife. (Fig. 2d.)

**Fourth Step.** The threadcarrying instrument is withdrawn through the primary stab incision, and the suture encircling the vein escaping through the primary incision is tied. (Fig. 2e.) The ends, cut short, will disappear underneath the skin. No sutures are required for the small skin incisions. (Fig. 2f.)

The vein sector between two ligations is then divided by subcutaneous dissection using a narrow blade (No. 11 Bard-Parker Blade) or a cataract knife.

There should be no bleeding throughout the procedure. If it occurs the vein wall has been injured. Hemorrhage is always controllable by compression and elevation of the leg for a few minutes. In cases where the vein wall is only partially caught in the ligation, the end results are satisfactory and compare favorably with the end results

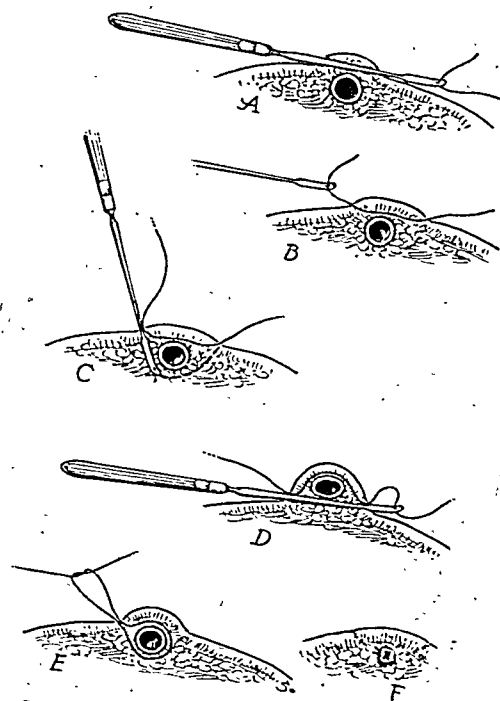


FIG. 2. Schematized drawing of technic of subcutaneous ligation of a varicose vein by special ligation knife.

of the subcutaneous dissection methods of European authors.<sup>5</sup>

The operation must be done under strict aseptic precautions and not without proceeding high ligation. In cases where the veins collapse in horizontal position, the operation should be done on the hanging extremity. The patient must under all circumstances be kept ambulatory, aided by adequate supportive bandages.

In a recorded series of fifty-five subcutaneous ligations, the following observations were made:

There was neither a postoperative embolism nor death. The discomfort was slight, not necessitating heroic anodynes.

In seven cases (12.7 per cent) the vein wall was injured without any untoward sequelae.

After one week the ligation site showed slight infiltration, which gradually disappeared after two to six weeks. It appeared that silk and cotton ligatures caused less tissue reaction.

Three ligations (5.8 per cent) showed a low grade infection which subsided by conservative treatment after three weeks.

The veinsector below the ligation was usually thrombosed.<sup>3</sup>

The cosmetic results were satisfactory, the minute scars having become almost unnoticeable after six months. There was no case of keloid formation in this series.

In one case the cotton ligature, protruding through a minute opening, had to be removed after eight months.

Remaining venous sinuses between percutaneous ligations had to be treated by sclerotherapy. The number of postoperative injections, incidentally, was markedly reduced in comparison with the cases where high ligation alone was done. This confirms the statements of L. Ferguson and others.

In two cases where repeated sclerotherapy did not effect obliteration of the varices, subcutaneous ligation accomplished a cure.

## SUMMARY

High ligation of the great saphenous vein at the fossa ovalis, multiple sectional phlebectomies, supplemented by multiple percutaneous ligations, using a special ligation knife, is described and recommended as a surgical procedure for the eradication of varicose veins.

The retrograde injection of sclerosing agents following high ligation is abandoned as being too hazardous and defeating the aim of keeping the patient ambulatory. Sclerotherapy has to be done as a postoperative measure.

Multiple ligations increase the effect of postoperative sclerotherapy as they reduce the retrograde venous pressure more efficiently than high ligation alone.

The use of a specially designed ligation knife renders the procedure simple, saves time and aids keeping the patient ambulatory.

The veinsector between two hypodermic ligations is divided by subcutaneous dissections from a lateral stabincision, using a narrow blade or a cataract knife.

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# APPARATUS FOR RAPID CONSTRUCTION OF MOLDED SPLINTS

LIEUT. COMMANDER MICHAEL GOSIS  
MEDICAL CORPS, UNITED STATES NAVAL RESERVE

THIS apparatus was quickly and cheaply constructed by a carpenter's mate on our base according to dia-

wooden block on its axle. The number of rolls used depends on the thickness desired.

If splints longer than 36 inches are

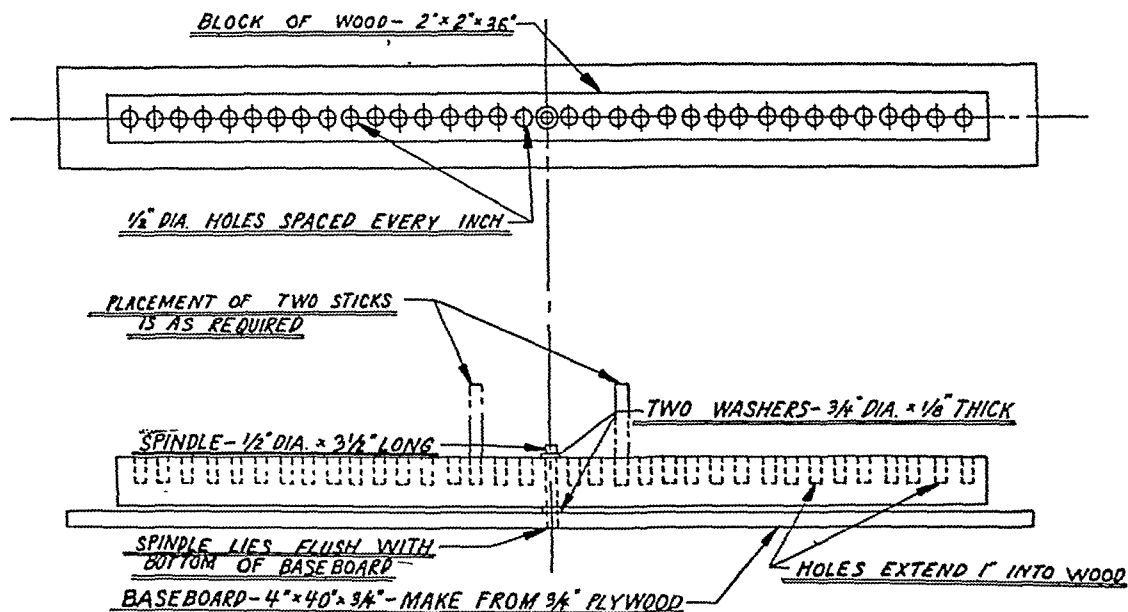


FIG. 1. Illustration of apparatus for molding splints.

grams reproduced here. Essentially, it consists of a block of wood with holes placed 1 inch apart, for a convenient length of 36 inches. Into any two of these holes  $\frac{1}{2}$ -inch dowel pins, 8 inches long, are inserted. In rolling a molded splint, the desired length is marked out by inserting the dowel pins in the appropriate holes in the wood block. The basin of warm water is placed underneath the rotating block so as to collect plaster drippings. The plaster roll is dropped into the water and can be used immediately, for it is thoroughly moistened as it is pulled out of the water by the rotating pins. One end of the plaster roll is secured to one pin and this pin is used as a handle to rotate the

required, let us say 54 inches for example, the pins are placed 27 inches apart and a double thickness is rolled, after which the plaster is split at one end with a scalpel and unfolded to a full 54-inch length.

Another use for this apparatus at a busy station is for cutting dry plaster bandages to required lengths and storing them flat, ready for quick construction of molded splints for wrist and hand fractures. When used, ten or twelve pieces are lifted out, dipped in water for a few seconds and immediately molded to the extremity.

One corpsman working alone can roll a molded splint with this apparatus in a fraction of the time it takes two to roll it on a table top.

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## Editorial

### REPORT OF A MEETING

CASTING about for thoughts and ideas for the purpose of translating them to a printed page, I was afforded the opportunity by attending the annual meeting of the New York and Brooklyn Regional Fracture Committee of The American College of Surgeons at the Einhorn Auditorium of the Lenox Hill Hospital.

Ideas were to be had for the asking. For instance it was noted that fractures of the os calcis constituted the second unsolved problem of fracture treatment, (the first being by implication, intracapsular of the hip, which has presumably been solved by the propaganda of the late Royal Whitman and the technical achievements of Smith-Petersen and others).

I gathered that the conventional methods of treatment of comminuted fractures of that bone contributed little or nothing to the eventual outcome. The residual disability was pain and the secondary and comparatively unimportant disability was the loss of motion in the subastragaloid system of joints. This coincided with my long observation upon the behavior of these fractures.

Observation of the essayists that the standard operation of subastragalar arthrodesis was sometimes unsatisfactory from the standpoint of relief of pain, they

proposed and practiced alcohol injections and later resections of the posterior tibial and sural nerves. In four of seven cases the results were reported as satisfactory. It might be questioned whether this compares at all favorably with the results of arthrodeses, which seek by bony fusion to eliminate the small remaining amount of painful motion in a weight-bearing joint which has been disorganized by trauma.

A similar idea was presented to embrace the subject of malunited or otherwise unfortunate results of fractures about the ankle. I may here recall that a fracture committee in England some thirty years ago found that 29 per cent of such fractures sustained by the London Police force rendered those men unfit for return to their regular duties. The essential pathological condition as presented by the essayists was a late traumatic arthritis of the ankle joint whose cure lay in only one direction—arthrodesis of this joint in a favorable position which resulted in painless and functionally useful extremities.

Then there was an injury of a non-weight bearing joint, the elbow, which occurs mainly in childhood. This is a fracture of the upper third of the ulna with dislocation of the head of the radius. The desirability of open operation to correct both conditions was stressed, but it also ap-

peared that the occasional failure to recognize and treat the dislocation was not so great a tragedy as might be assumed. It may well be that this is due to two things (1) youth and (2) a non-weight bearing joint.

The essayists who presented the subject of rehabilitation of the injured covered a field far wider than such a title implies. Indeed, this field has been called "the third phase of medicine," the first being assumed to be preventive and the second, definitive treatment. This third phase covers a good deal of endeavor mainly *seeking to return the individual to economic usefulness*, to make the most of what he has left after the ravages of disease or traumatism have left him with

a greater or lesser handicap, either temporary or permanent in nature.

A department such as this seeks to synthesize the functions of the physician, physiotherapist, occupational therapist, teacher of physical education, vocational guide and the inspired humanist. The demonstration appeared to be eminently successful and the synthesized effort will undoubtedly make a real contribution to the practice of medicine.

Unfortunately, this writer was not able to attend the afternoon session which included a presentation on the *reconstructive surgery of the hand and the use of a new nail for the treatment of intertrochanteric fractures of the hip*.

ARTHUR KRIDA, M.D.



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# Original Articles

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## EXPERIENCES OF AN ARMY DOCTOR IN THE EUROPEAN THEATER OF WAR\*

ELLIOTT C. CUTLER, M.D.†

Moseley Professor of Surgery, Harvard University

BOSTON, MASSACHUSETTS

WHEN I was informed that this was a meeting dedicated to returning officers I was on the horns of a dilemma for a suitable topic. The choice seemed to lie between a story of our experiences in the European Theater and the future of the medical service within the Veterans Administration, a national medical responsibility in which I am deeply interested and connected with for the present in an official capacity. I hope I have not gone amiss in electing to speak of our experiences in the European Theater. It appears to me that the past and present problems of military medicine, the relation of civilian doctors to the Surgeon General's office, the procurement of doctors and their proper use in war constitute a responsibility for the profession of medicine which it cannot escape. We must not make the same mistakes in any future war; and with the opportunities I have had to observe the set-up and function of the Medical Corps of the United States Army in this war, I have a deep regret that the lessons learned in the first war were not handed down for the benefit of our people at the time of the second world war. It seemed to me that this problem is more urgent than the problems of the Veterans Administration (which will certainly remain with us for years to come); we must establish now, before we have forgotten what we learned, ways and means of helping the Surgeon General's office and the Regular Army

Medical Corps before our impressions have faded and lost their strength.

Any recital I can give of military medicine must in its specific details relate to the European Theater where I was privileged to serve. And I would be remiss in my affection for and pride in the 16,000 odd medical officers in that theater did I not champion their cause. I can now confess openly that I went to the European Theater under the misconception that the first battles would take place there. However, the interval from June, 1942, to June, 1944, when we had no ground force activity, was highly beneficial to the American soldier later to come there for the greatest battles of the war. It may be that this delay which gave us time to prepare, was a major reason for the excellent care that was given later and for the great reduction in the mortality rate among our wounded.

In this interval several outstanding lessons were learned. From visits to the Mediterranean Theater we learned much about the value of hospitals far forward for the seriously injured or "non-transportables" and from the experience of the landing operations in Sicily and Salerno we were able to plan better our care of the wounded in the Normandy landings. From the Medical Mission to Moscow we learned of the value of specialists in the most forward hospitals and a great deal of the value of keeping all wounded who could be

\* Presented at the Annual Meeting of the Academy of Medicine, Cleveland, Ohio, May 17, 1946.

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returned to duty within one or two weeks in divisional medical units far forward. From them we learned much also of bravery, blood banks and air evacuation. Finally, during these two years, we had the great opportunity of caring for and studying carefully the steady flow of wounded from the 8th Air Force. This Air Force, which began to function against Germany in the summer of 1942, deserves the greatest credit and our happy relations with it, which resulted in all the European Theater of Operation consultants teaching in the 8th Air Force Medical School, stem largely from the fact that Dr. Herbert Wright, of Cleveland, who was the responsible advisor in professional matters to this 8th Air Force, shared his problems with the office of the Chief Surgeon of that theater. Our mutual understanding itself could not have overcome the ever present desire for complete independence of the Army Air Force had it not been for the superior intelligence and devotion to the general cause of the 8th Air Force Surgeon, General Malcolm E. Grow. During these two years we had the opportunity to study a steady flow of casualties under fairly ideal conditions in the six Army hospitals, located in East Anglia, assigned to the Air Force. In the first place we could be sure the surgical staffs were good; next we could have competent laboratory studies and finally patients could be kept long enough to determine results. These three desiderata, competent personnel, laboratory service and a period of postoperative observation, were denied us later on when on the continent the numbers of wounded reached to 40,000 in a single month, when as many as 50,000 patients were moved by airplane in a single month and when 200,000 patients in our hospitals made it impossible to do more than hope the education and information already given to units would bring forth the results we expected and desired.

Moreover, this period of waiting which to others may have seemed ennui, was crowded with activity. A European Theater

of Operations medical society was established, at the meetings of which the most recent experiences in all theaters were discussed. Topics discussed ran all the way from how to avoid aero-otitis media, which was a curse to the Air Force, to what to do with pilonidal sinus. These meetings, originally held in one of the General Hospitals, became tremendously popular; at first so many delegates from each area were permitted to go; later, because of difficulties in travel, the general meetings were restricted to area or base section meetings. At the same time, remembering the educational advantages in World War I of certain scientific, professional meetings in Paris, some of which I was allowed to attend, it was finally arranged that the Royal Society of Medicine would sponsor once a month an Inter-Allied Medical Meeting, at which the most up-to-date military medical matters brought to us by officers returned from active theaters would be discussed. All this time, the consultants in the office of Major General Paul R. Hawley, the Chief Surgeon of the European Theater of Operations, were compiling a Manual of Therapy based on the original manual of therapy put out by the Surgeon General's office, but modified by what we had learned from others and what our experience with the 8th Air Force casualties had taught us. In this manual, therapy was divided into that done on the battlefield or in division medical units and that to be done in hospitals, and further, it differed because we were successful in getting the Chief Surgeon to write a foreword making obligatory the following out of the instructions contained in the manual.

We learned that Chief Surgeons in other Theater Headquarters and Army or Operating Headquarters in other theaters had difficulty in making their medical rulings stick and I am certain that in the European Theater of Operations the time available for general and specific education, the time permitting us to persuade the Chief Surgeon of the necessity for a standardized

therapy, and the time to educate our medical officers to this point of view was a major factor in the happy results which we can now discuss. We can all hope that by the time of another war, the medical corps of the Regular Army will have so ordered its house that in any given theater of war medical policies can be dictated by a chief surgeon who will be willing to accept advice from experts recently inducted from civilian life.

For those of us who have been through this experience, it is a major responsibility that we now so assist the Office of the Surgeon General and so influence the Secretary of War that the Office of the Theater Surgeon shall have the power to order the care of the sick and wounded properly, untrammelled by interference from non-medical combat generals. The attitude of combat commanders towards medical advice cost the European Theater 45,000 soldiers incapacitated from combat duty through that disorder known as "trench foot." In the Pacific Theater, the unwillingness of combat commanders to take proper precautions against the mosquito decimated many excellent divisions brought at great risk and with great difficulty to that theater of war. Our responsibility extends further for we must see to it that the organization of the Office of Chief Surgeon of the Theater is properly staffed with experts and further that the Theater Surgeons themselves have a training and education which will leave them receptive to expert advice in the many phases of medicine in which the regular Army officer himself can never, by virtue of his work, be an expert.

You may have seen my Hunterian Lecture recently published in *Surgery, Gynecology and Obstetrics*. Even if you have, I trust these charts and figures, which are here somewhat amplified, will be acceptable. They will, I hope, furnish a stimulus for our continuing responsibilities.

Figure 1 reveals some general statistics of the Armed Forces from 1942 through 1945. It is shown in order to emphasize the

tremendous load which occurs under active battle conditions, thereby graphically bespeaking competent preparation for the ordeal. In preparation for such an ordeal, Medical Headquarters must seek to set up the possible casualty rates and then push medical care as far forward as possible. This becomes dangerous and highly difficult in amphibious landing operations as all know who have been through such hazardous affairs. Our most highly trained unit, landing in Normandy shortly after H-hour, lost all of its three vehicles at the time of landing. One was lost overboard, one was hit by an 88 mm. shell on landing, and one was captured by the enemy. All the same, the Medical Department must provide care for "non-transportables" under such circumstances immediately on the battlefield or on a ship off shore which can be reached in a short period of time. In providing for a great undertaking, as exemplified by the figures on this chart for the European Theater, it is essential that medical personnel be briefed or have some advance knowledge equal to that of the combat forces. Lack of information until the last minute was certainly the cause of much suffering and many deaths, often needlessly so. I do not believe the American people will tolerate in another war the entirely secondary position relegated to the medical department by many generals in this war, as if the lives of American citizens were totally expendable. We have no desire, as doctors, to interject ourselves in any way into technical and combat matters but, as those responsible for the care of wounded fellow citizens, we must be permitted enough information to prepare ourselves for what our country expects of us. Figure 1 reveals the most recent statistical evidence I can secure and I will remind you in looking at it that comparisons of such figures are undesirable and foolish without a knowledge of time relations and other factors. However, the great disproportion between the percentage of those admitted for disease in the various theaters emphasizes the greater medical

# GENERAL STATISTICS — UNITED STATES ARMY 1942 - 1945

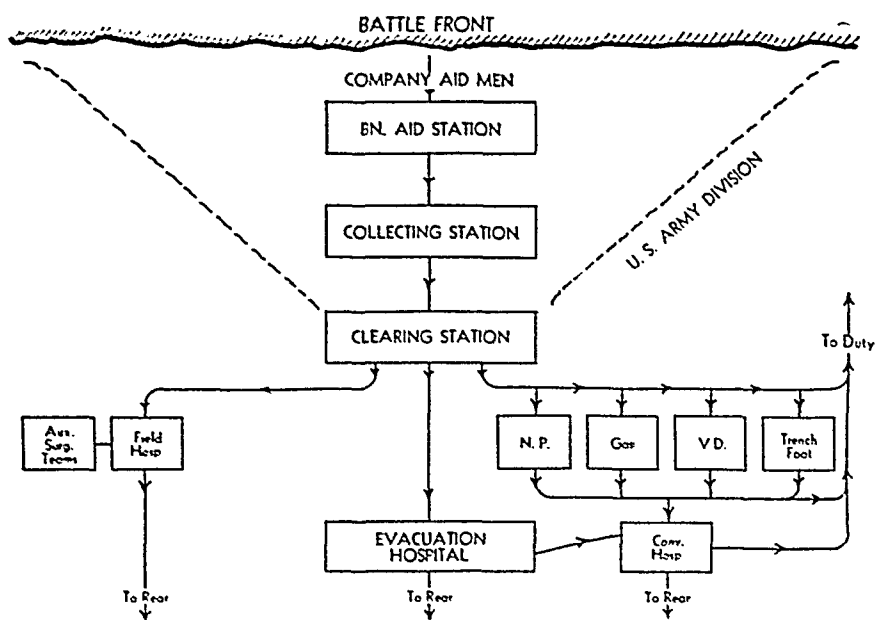
	<i>European Theatre</i>	<i>Mediterranean Theatre</i>	<i>Pacific Theatre</i>
<b>1. Admissions to Medical Units</b>			
All Causes	2,935,313	1,529,105	2,599,768
Disease	2,157,221 (73.4%)	1,212,993 (79.3%)	2,159,443 (82.7%)
Non-battle Injury	382,523 (13.0%)	185,408 (12.1%)	332,008 (12.7%)
Battle Wounded	395,569 (13.4%)	130,704 (8.5%)	108,317 (4.1%)
<b>2. Dead (to May 1945)</b>	113,952	37,849	
<b>3. Fixed Beds Available     (30 April-1945)</b>	200,350	29,000	
<b>4. Ground Force Strength     V.E. Day (May 7, 1945)</b>	1,703,613	178,205	

FIG. 1. Some general statistics of the Armed Forces from 1942 through 1945.

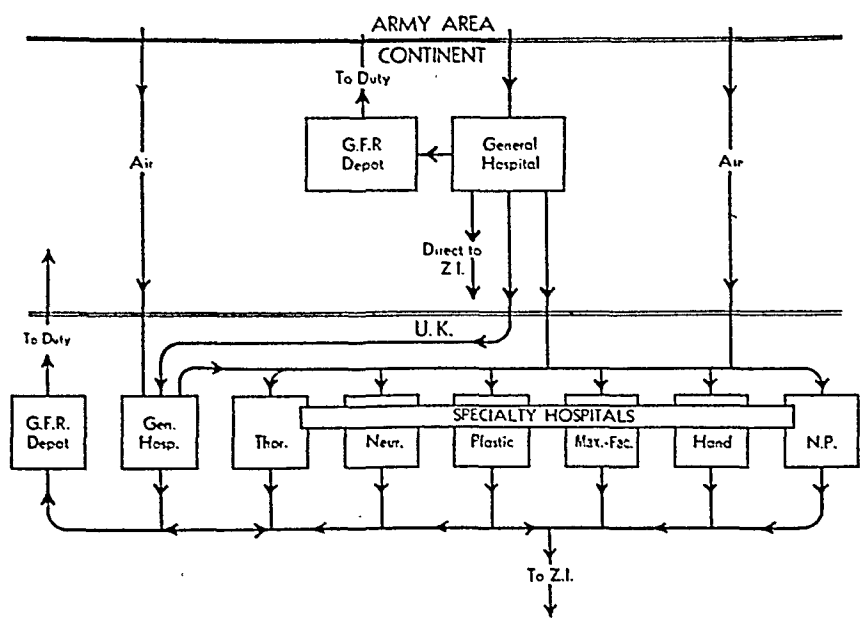
problems in the Pacific Theater, perhaps mostly that of malaria; and that the figures for the European Theater, though they cover three years, cover less than one year of battle. The total percentage of battle wounded in the European Theater on the chart is 13.4 per cent and yet during the active days of battle there were times when the percentage of wounded admitted exceeded those admitted for disease.

Figures 2 and 3 reveal the course of a wounded soldier from front to rear. Figure 2 shows the official forward organization and the medical elements within a combat Army. Wounded men, picked up in the battlefield by highly trained Company Aid men, pass through the Battalion Aid Station, usually directly to the Clearing Station. In evaluating the reasons for the diminished mortality a considerable share in our improved results must go to the medical elements within the Army. I would be remiss in my devotion to the Company Aid men did I not mention that their competence and valor on the battlefield were a major factor in the reduction of the mortality rate. Though not classed as combat troops, they accompanied the combat soldier everywhere and the loss of some 2,000 of such Company Aid men in the European Theater testifies to the brave performance of their task. At the Clearing

Station, a primary function other than to see to the comfort of the patient and that his dressings are secure and hemorrhage is not occurring, is sorting. Here the most seriously injured, largely those injured in the chest and abdomen or with multiple severe injuries whose blood pressure cannot be made satisfactory for an ambulance ride further to the rear, are sent to the adjacent Field Hospital where surgical teams from a surgical group give them immediate surgical attention. At this level whole blood is first available and it proved of inestimable value in saving life. Those who were seriously damaged but can withstand transfer proceed further to the rear to the Evacuation Hospital. The Clearing Station retains in attached small units those whom its medical personnel think might be returned to duty within perhaps one week or ten days. These may be divided into neuropsychiatric cases, soldiers with venereal disease or the less severe forms of trench foot or any other special medical condition which the terrain or some local condition brings forward. Attached also to the Army is a Convalescent Hospital which will retain for seven to ten days individuals who cannot be returned to duty within twenty-four or forty-eight hours. The Russian Army held soldiers longer in this forward area and all military men agree



United States Army Medical Organization. I, Forward area (Army).  
FIG. 2. United States Army Medical Organization. 1. Forward area (Army).



United States Army Medical Organization. II. Communications Zone (Continent and United Kingdom).  
FIG. 3. United States Army Medical Organization. II. Communications Zone (Continent and United Kingdom).

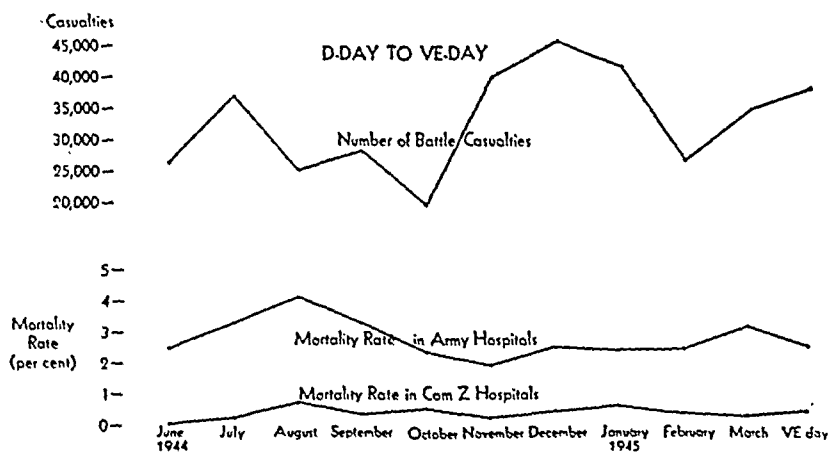
that a soldier who once goes down the line beyond these units returns with difficulty.

Figure 3 reveals the fixed hospitals of the rear. These are either General or Station hospitals. They are best grouped into centers of seven, eight or ten general hospitals, where only one specialist in each of the various specialties such as thoracic surgery, neurological surgery, plas-

tic surgery, facio-maxillary surgery, etc., need be provided for the entire center.

From such hospitals those who could be returned to duty under the Theater policy of evacuation, which for a long time was 120 days in the European Theater of Operations but eventually, when we were tight for beds, dropped to sixty days, went to Ground Force Replacement Depots and thence back to duty. If they could not be





Battle casualties, Medical Department, European Theater of Operations, excluding K.I.A. Total battle casualties, 372,556; mortality rate, 3.9 per cent.

FIG. 4. Battle casualties Medical Department, European Theater of Operations, excluding K.I.A. Total battle casualties 372,556; mortality rate 3.9 per cent.

made fit for duty under the Theater Evacuation Policy, they were returned to the zone of the interior.

Figure 4 reveals the battle casualty statistics in the European Theater of Operations from D-day to VE-day. The mortality rate was 3.9 per cent for 372,556 officers and men reaching medical installations alive. Of these, one-half of 1 per cent died within the medical element of the combat division, that is, the Battalion Aid Post, Collecting Station or Clearing Station, 2.7 per cent died in Army hospitals, that is, Evacuation and field Hospitals, and less than 1 per cent in the General and Station hospitals in the rear area. The chart depicts the enormous load which must be borne by the medical department, for 45,000 casualties in a single month is sure to raise a lot of trouble no matter how carefully one plans for medical care. The pressure of such a load means frequent changes in policy. As beds fill up, and over 200,000 of ours were filled at a single time, headquarters must worry about where the next 40,000 are to go. Some will have to be evacuated immediately to the zone of the interior by air or whatever other means is at hand. These decisions must be reached daily, not in the sort of quiet life the ordinary doctor lives during his civilian years. The pressure of such a load is exemplified

by the fact that 50,000 sick and wounded personnel were moved in the month of April, 1945, by air alone, representing our frantic efforts to clear the hospitals on the continent for a bloody finish.

Figure 5 reveals the regional distribution of wounds in the different theaters of World War II. The large black frame covering the anatomical distribution for each of the three theaters represents the body surface of that anatomical area. If missiles were uncontrolled and the total body exposed, random hits should occur in proportion to the surface area; but variation in the tactical situation or the dead who are not counted in such a study make for the variations between the various theaters. Note, for example, the high percentage of hits on the head and neck for the South Pacific which might mean jungle fighting where the first part of the body seen was the face and where snipers strategically placed produced heavy damage on advancing troops.

Figure 6 reveals the difference in woundings between Air Force and Ground Force troops and is of course significant to us in view of the possibility of protective armor for Infantry as well as the Air Force. Note the low figures for chest and abdomen for the Air Force. This was in large part due to the body armor developed by the 8th

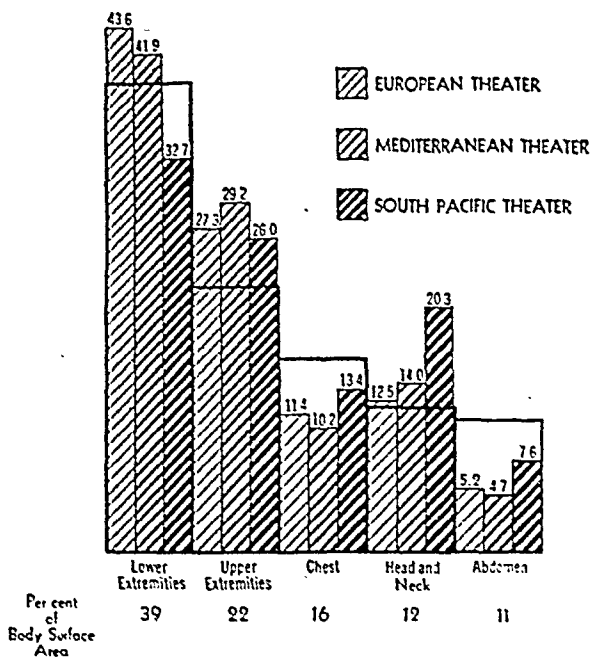


FIG. 5. Regional distribution of wounds in WIA (wounded in action) casualties in different theaters of World War II.

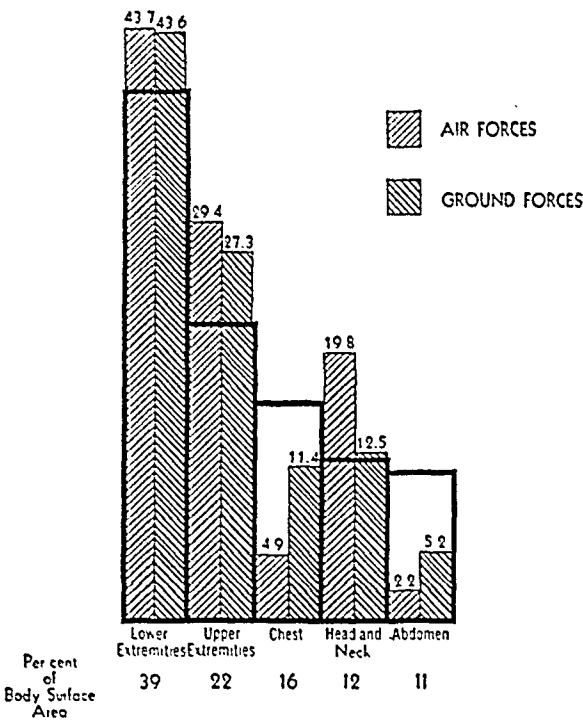


FIG. 6. Regional distribution of wounds in WIA (wounded in action) casualties sustained by the Air and Ground Forces during World War II.

Air Force in the European Theater of War, largely under the stimulation of Brigadier General Malcolm E. Grow, Surgeon for this Force. The high percentage of head and neck damage is difficult to explain except on tactical reasons. Large bombers were often heavily damaged at the nose and injury occurred not only from the missile itself but from fragments of the plane, including bits of plexiglass which were driven into members of the crew.

Figure 7 reveals further studies of bomber crews and gives percentages for those who wore armor as against those who did not. Note the great saving in the wounds of the chest and abdomen when armor was worn. This leads to the indisputable deduction that many of the missiles were of low velocity and though they might seriously damage an individual through the unprotected skin, were easily deflected by even light armor. At the bottom of this chart the percentage calculations are given of those who were actually saved, from wounding on the left or death on the right, when suitably protected with armor. It is now no secret that a light body armor was in production by V-J day for Infantry forces under the stimulation given by these figures.

Figure 8 reveals an important function of the Medical Corps and one which is not much discussed or thought of by civilians, that is, the percentage of those admitted to hospital for wound, disease or non-battle injury who may be returned to duty and strengthen the combat forces. This chart reveals the distribution of about 400,000 hospital cases sent to duty through the replacement command in the European Theater of Operations between June 23, 1944, and May 4, 1945. Note that of the 142,000 battle casualties, almost 80 per cent were returned to duty whereas few of the neuropsychiactrical cases were judged capable of a second go at combat warfare. The return to duty of men who have reached the hospital is one of the important functions of the Medical Corps, for in confronting the enemy, superior force may be the determining factor in shortening the war and therefore eventually decreasing the amount of suffering and death which is the usually accepted function of the Medical Department.

Figure 9 has to do with a method of judging the effectiveness of procedures not commonly applied to civilian statistical

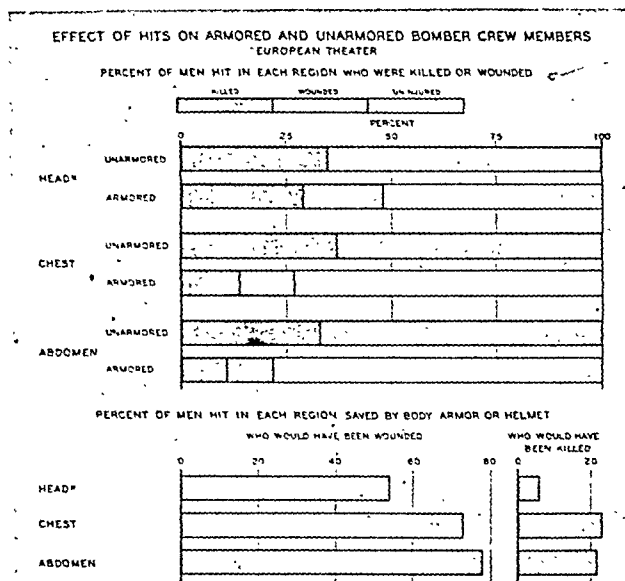


FIG. 7. Further studies of bomber crews, with percentages for those who wore armor as against those who did not.

studies. The column to the left represents the secondary closure of soft tissue wounds. Note that where the percentage of primary healing is high (the left hand column, 90 per cent), only 60 per cent of the wounds were closed; whereas where the percentage of primary healing is low (the furthest column to the right, 90 per cent with primary healing), 90 per cent of the wounds were closed. Similar figures are presented on the right dealing with the closure of wounds of compound fractures. Considerable rivalry takes place among hospitals as to the percentage of primary healing in this important work; for if soldiers are to be returned to duty, their wounds must be closed early. Careful investigation revealed that those hospitals which thought they were good because over 95 per cent of their admissions had secondary closure and were satisfactory, were attempting to close only a small percentage of the wounds. In referring again to Figure 9 you will note that though the hospital which closed 90 per cent of its wounds had only 90 per cent satisfactory primary healing, it actually salvaged 20 per cent more individuals and therefore should be credited as a much better professional group. A similar yard-

stick of salvage may be applied to all forms of battle wounding. For example, the Evacuation Hospital reporting to Headquarters that the fatality rates for abdominal woundings were down to 12 per cent thought it was very good and took personal satisfaction that this rate was lower than a nearby Evacuation Hospital where the mortality rate for abdominal woundings was 18 per cent but careful investigation of such hospitals always revealed the same finding. Where the rate was low, the surgeon was accepting only the good risks and soldiers were dying who might, with adequate surgery, have lived. This attitude toward statistics is not new to the civilian doctor for we see surgeons writing up mortality rates for operations for appendicitis with a rate under 1 per cent, whereas careful analysis will reveal that a great number of appendices removed were interval appendices or removed during another operation and had nothing to do with the figures for operation for acute appendicitis. When one deals with thousands of figures, standards are established relatively early within which mortality figures should fall. A recent study submitted to me of abdominal wounds reveals

the narrow limits within which divisions occur. Of 877 penetrating abdominal wounds in a Field Hospital, 6.49 per cent died without operation while figures in 284 abdominal wounds in a nearby Evacuation Hospital showed that 5.6 per cent died without operation. The slight discrepancy between these figures was undoubtedly explainable on the tactical situation and the pressure for work. Thus the Field Hospital with a slightly higher rate receives on the whole the more serious cases, for those that are critically ill cannot travel to the Evacuation Hospital. Moreover, in a Field Hospital, under conditions of great pressure with limited surgeons available, there was frequently more delay before a given patient could reach the operating table. Of 443 intra-abdominal wounds carefully studied by these two hospitals, and the combined thoraco-abdominal wound was excluded, the mortality rate was 16.7 per cent. This I think would be the average for the European Theater of War. Those who report a lower figure probably refused surgery to some of the more serious risks that might have been saved and those who had higher figures may not have been quite as competent surgeons.

I shall not have the time to enter into all of the professional surgical procedures which had to do with improved statistics but would like to attempt to analyze the factors which were favorable to the high rate of recovery, for the mortality rate of 3.9 per cent was less than one-half of that in World War I. This mortality rate is figured on casualties who reached a medical unit alive and does not concern those dead on the field of battle. As stated earlier, of this 3.9 per cent mortality about 0.5 per cent died within medical elements of the combat division; 2.7 per cent died in Army hospitals (Evacuation and Field Hospitals), and less than 1 per cent in the Station and General Hospitals in the rear areas.

The factors playing a rôle in this highly desirable low mortality rate would seem to be as follows: first, resuscitation, covering

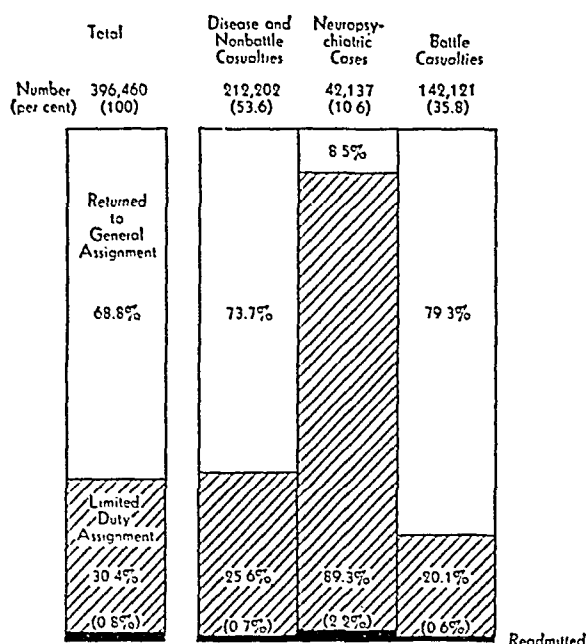


FIG. 8. Disposition of 396,460 hospital patients sent to duty through the Ground Forces Replacement Command, European Theater of Operations, June 23, 1944, to May 4, 1945.

the proper treatment of patients in shock and all who have been severely damaged, largely through the intelligent use of whole blood and plasma in effecting a restoration of blood volume; secondly, better first aid on the battlefield by the Company Aid men, who in this war had been thoroughly trained and prepared for their task. It is of interest to note that, though in the United States Army additional pay was finally granted to all combat troops, the Company Aid men were not given this increase though they were always present with their combat fellows, landing with them on beach heads under heaviest fire and accompanying them everywhere on the battlefields. The reaction of combat troops to this was a great compliment to these men of the Medical Department, for repeatedly in certain divisions the combat men offered to pay this increase out of their own pockets to their fellow soldiers who were accompanying them. A third factor in the cause of the lower mortality rate seemed to be the use of penicillin and the sulfonamides which produced such a beneficial check on the horror of infection. A fourth factor was the improved method of transport from the battlefield. It may be noted that, almost universally, at least in

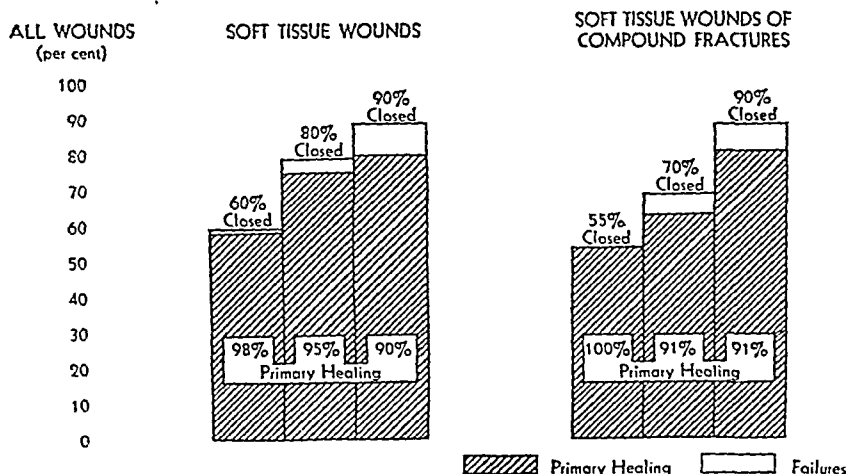


FIG. 9. Increased "salvage" with great proportion of secondary closures attempted. (Based on representative data from various General Hospitals.)

the European Theater of Operations, converted jeeps were used as ambulances. In this forward area these were able to travel directly to the battlefield, though often at great risk to the drivers, pick up the wounded and transport them immediately to a hospital, thereby greatly reducing the number of hours between injury and surgical care. A fifth factor was unquestionably the excellent general physical condition of the United States soldier. This may have been partly due to the period of pre-combat physical training which placed the soldiers, before going into battle, in the condition of athletes with the highest possible resistance. In the sixth place, one must consider the factor of better surgery. Under this heading and for emphasizing the difference between the two wars, I would place the advance of anesthesia as a major factor. Expert professional anesthetists were present in all Field and Evacuation Hospitals. They were equipped with the most modern apparatus which they used intelligently. Lastly, in the factors contributing to a low mortality rate, I would put the advances in surgical technic. In this field, the widespread general information in the fields of neurological, facio-maxillary and thoracic surgery is a chief addition to our surgical technic since the last war. It is true that Harvey Cushing, in the field of neurological surgery, and Kazanjian, in the field of facio-maxillary

injuries, had pointed out certain signposts in these specialties which later bore their fruits in the better education and training of the specialists of these important branches of surgery.

It behooves us to try to pay our debt here to the scientists who labored in the laboratories to perfect the methods which brought this relief to the wounded soldier, and, also, we must give full justice and gratitude to the many animals whose rôle in experiments produced fruits so beneficial to mankind. The increased longevity of man has, in large measure, come about through the investigation he has carried out on animals, but never were these fruits put to greater use than in the recent military experience. It may be conservatively stated that in the European Theater of Operations, 25,000 American boys are now home with their families who, save for the animal experimentation between the two wars, would today be occupying graves on foreign soil. These are the men who, in relation to the improved mortality statistics, would have died under the therapy available in World War I. The chief factor in the reduction in mortality was the universal use of blood and plasma. The feasibility and value of plasma as a substitute for blood (plasma being a substance which could be kept indefinitely and shipped anywhere without deterioration) was established by experimentation upon

animals. By creating blood loss in animals and then replacing this loss with plasma, it was learned how much plasma was required, the safety of the procedure and the value of this replacement. When we come to the use of whole blood to replace blood loss of the wounded soldier and thus make him a safe risk for necessary surgical procedures, again innumerable experiments upon animals were required in order that the right type of blood be used and the right preservatives be mixed with the blood in order to keep the cells alive until it could reach the wounded soldier. Blood and plasma could never have been used for the wounded soldier in the wholesale way it was except through animal investigation.

Another important factor in the diminished mortality was the use of the sulfonamides and penicillin. It is unnecessary to elaborate here the innumerable experiments carried out with these two important antibacterial agents, but it is clear to all doctors that such experiments should continue for a long time, since the full use of such agents is not yet clearly defined; in fact, the advent of a new agent, streptomycin, will require years of experimentation in order to determine in what infection each of the three antibacterial agents is most favorable. It can be stated here by one who saw the wounded in both wars that the difference in the amount of infection was a dramatic event. Moreover, it was not just different battlefields or other methods, because our opportunity to see wounded prisoners of war in huge numbers in whom these agents had not been used graphically depicted the advantages of such agents.

Further animal experiments in the period between the two wars opened up new fields for surgical care. Cardiac surgery was one of these fields and the safety of such work was first established by experiments upon animals. Beginning in 1921 an operation was elaborated upon for the improvement of valvular disease in human beings and the experience which we gained from these experiments was applied later to this field for work in human beings. Now, surgeons

undertake procedures upon the heart with the same safety to the patient as when other surgical procedures are carried out; but without the signposts for safety having been established by operations upon animals preceding the attempts on humans, this field would have remained a closed book, and the soldiers whose lives were saved by direct operations upon the heart and the area about it would have been lost.

Since cardiac surgery is merely a fragment of thoracic surgery, we must recall the immense additions to our knowledge concerning the methods under which the thorax could be opened with safety. This increase in knowledge has come through animal investigations during the period between the two wars. Thoracic surgery at the time of the last war was something to which the medical officer was forced, without proper anesthetic apparatus, in an attempt to save life without the means for keeping the lung expanded in open chest procedures. Consequently, the mortality rate was a heavy one, for only hasty and improvised technical operations were possible in the presence of a collapsed lung. Now, when one consults a mortality rate of perhaps not more than 30 to 35 per cent for the combined thoraco-abdominal procedure, which is the operation of greatest magnitude forced upon the military surgeon, we can best evaluate the progress that has been made in this field.

Finally, I would like to speak of the miracle which has occurred in eliminating tetanus from military surgery. Let me recall some figures for you: In our Civil War, the mortality rate was from 89 to 95 per cent. Shortly before World War I, under the benefit of antitoxin which was discovered and elaborated upon by the use of animals, the mortality rate had dropped to between 40 and 80 per cent. During World War I, large statistical evidence showed a mortality rate of 20 to 58 per cent; but, in this second World War, there were only eleven cases known to occur among 10,700,000 men. Of these

eleven cases, five had been given toxoid and six had not. Moreover, in these eleven cases, there are only records of four deaths; two of which occurred in individuals who had received the basic series of toxoid but no booster dose, and two in individuals who had not received even the basic series. This is, in my mind, one of the greatest miracles of modern medicine. The basis of the establishment of a proper toxoid rests squarely upon animal investigation, and no greater debt could be acknowledged to our friends in the animal kingdom than this advance for the good of humanity.

It is a pity that, in an enlightened world, the incalculable benefits to humanity are not generously appreciated. The evidence presented by these statistics from the Armed Forces and particularly the presence in our midst of 25,000 living soldiers from the European Theater of Operations who, without the benefits given by animal investigation, would not now be here, is written boldly in medical history. This is incontrovertible testimony that the work of scientists and the rôle they have played in the destiny of man depends in great measure on their chance to use the lower animals for man's comfort, health and happiness.

With this background, it would appear that we should rest fairly well satisfied with our efforts. Yet those who know the inside of the story can never feel that way about it because it could have been so very much better in many ways. If one has to be concrete about the defects of the medical set-up in the Armed Forces, it perhaps can be boiled down to wastage which includes wastage of both personnel and materiel. This wastage emanates from many sources. It is partly due to the improper setting up of tables of organization which, once set up, are rigid and no one can change. In one situation they may provide an unnecessary number of doctors; in another situation they fail to supply specialists; in another situation specialists are wasted. Thus, it may be that there could be some diminu-

tion in the number of doctors attached to the combat division. A beginning was made in the right direction when the Medical Administrative Officer replaced a Medical Corps Officer at the Battalion Aid Post but possibly further reductions in combat medical personnel can be made. Possibly, since we have pretty well proven to ourselves that the Collecting Station may not be as necessary as was planned at the end of World War I, several officers can be saved from each medical regiment. Moreover, in relation to the Battalion Medical Officer, there must be some form of rotation. It is unfair to the young medical officer to make him stay for three years as a Battalion Medical Officer. He should be rotated with men of his own age and training who are in the fixed hospitals in the rear. I fully realize the desire of combat leaders to have a fairly fixed staff comprised of officers in whom the men have faith and whom they can mold into a cohesive unit but at the same time, if those who rotate are properly chosen, there should be no difficulty along these lines. Doctors are gregarious people and if they do a good job win the respect of people almost immediately. Further, it is clear that we do not need specialists in every form of surgical specialty in each general hospital. It would be far wiser to assign a group of specialists to each theater headquarters and let the theater headquarters use them to the greatest advantage. Thus, if we had a group of general hospitals or hospital centers, one specialist each in neurosurgery, thoracic surgery, possibly urological surgery, etc., would do for each hospital center, thus saving valuable and highly trained personnel for use forward in Evacuation and Field Hospitals where their expert services will actually save life. Moreover, what tables of organization are set up must be fluid, changeable and pay less attention to rank. It must be well to remove rank from its fetish of time or of service. Possibly rank, as is true in the British Army, should go with the position held. If a man is a competent

specialist, then he should have rank irrespective of the number of years he has served or the time he has put in. And to continue our story of wastage, the right people must be put in the right spot. An expert anesthetist as the only doctor on an L.S.T. to care for heavily damaged people is silly and a physiologist, just because he has an M.D. degree, is little use as a battalion surgeon. Similarly, a neurosurgeon as a malaria control officer finds himself completely out of his depth. All of this is not a simple task for the best intentioned person would find some difficulty in knowing what to do with the pure obstetrician.

To continue our story of wastage, we must immediately lean towards a unification, under a single service, of all medical corps, including Army, Navy and Air. The conservation of medical, nursing, administrative and transportation personnel would be tremendous. We would thus stop the silly and unnecessary reduplication of hospitals, supply depots, transportation facilities, etc., and this leads us in turn to the matter of medical supplies. In days of peace, tables of equipment for medical units should be brought abreast of modern medicine and not the antiquated lists presented to us when this war commenced. But even when we have encompassed these difficulties of the proper selection of personnel, their proper assignments and have integrated all of the medical services into a common field, we have left that great and difficult problem of the procurement of the medical officer for service to his country. This too, needs entire revamping. The most competent combat officers, such as General Patton, have repeatedly told me that the only thing that counts in battle is what the combat officer, in his terse vernacular, calls "guts." He does not care for a great big, strong man if he is afraid of a noise. What he wants is some one with intestinal fortitude, who sees clearly his duty to his country and who has the psychological attitude to see his duty through even at the risk of

his life. Everything else is secondary to intestinal fortitude. I have repeatedly been requested by commanding generals to visit seriously damaged officers with useless hands or other similar wounds which apparently should render them unfit for further service, on the basis that this officer was worth more to the division than all the rest of the officers in it and that he did not need his hand to lead his men. This officer was competent because he had "guts." Possibly our induction boards need education along these lines and should learn that physical infirmities thought incompatible with military service are of little importance as compared with a man's psychological set-up. To accomplish all of these objectives is a herculean task and yet it remains a grave responsibility.

I have the hope that in some way we can accomplish two great objectives: The first is to establish as consultants to the Armed Forces of our country in peace as well as in war expert civilian doctors and surgeons who, by virtue of their being nominated to the Surgeon General's Office by the leading medical and surgical societies of this country, will bring with them the backing of such great groups. These men in turn can help set up the new tables of organization and tables of equipment and can modify them yearly according to shifting advances of modern medicine. Such consultants would have as a primary function the bringing together more closely of the regular army officer and the civilian doctor. These two groups must have common meeting grounds, should preferably be able to interchange their juniors between civil and military hospitals in order that the regular army medical officer receives a better education and learns to think about the general problems of medicine with the same eye as the civilian doctor. The impact of such a group of civilian doctors should greatly enlarge the education of the Regular Army Medical Corps.

And there are other immense problems. For example, we know little of what kills



men on the battlefield because no one has ever compiled a great study of large numbers of men found dead on the battlefield. We need teams of experts to conduct examinations of several thousand soldiers killed in battle under different conditions of combat and in different terrains in order to know what weapons are most lethal or what weapons injure the greatest number of the enemy. There thus far has appeared little liaison between the ordinance group who study the manufacture of weapons and the doctors who know how men die. Until the two get together, we shall not apply even the rudimentary principles of science to warfare. If we knew, for example, that mortars were the best weapon with which to attack an enemy because, let us say, it injured more of our men than any other weapon, then we could instruct ordinance to go out and make better, bigger and more mortars; but we have no such evidence and therefore can give no competent advice. War is still conducted without the benefit of this simple scientific survey. It is true that in this war scientists labored in their laboratories as never before in relation to military matters. Out of such efforts came the atomic bomb. But because we have the atomic bomb is no reason why we should sit down and give up thinking about the problems which I have enumerated. Perhaps the atomic bomb will be like poison gas—so bad that no one will

ever use it. If that should be true, the problems of the next war will be largely those of this war.

A final problem relates further to another phase of the wastage of medical personnel and materiel. In the United States we built at great expense large Army General Hospitals. Do we need them? Note that the Russians, whose injured vastly outnumbered ours, and the British did not do this. These countries provided such general hospitals as we did for overseas units but in the home country they enlarged their civilian hospitals and added a few Army doctors to help with the increasing load. The thinking behind this was intelligence of the long range type. With the war over, money spent on increases to civilian hospitals gives direct benefit to all the people whereas our system of providing strictly Army Hospitals leaves us practically nothing. We might benefit a good deal from further thinking on this problem. Had we utilized a similar plan, the grave shortage of hospital beds and nurses might not be such a nightmare now.

I hope I have shown you something of the courage, self-sacrifice and devotion of the great number of civilian doctors who served their country so well. At the same time, I hope I have made you envisage your continuing responsibility in the better use of doctors in a future war and the better care of the American soldier.



# STREPTOMYCIN

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THE search for an antibiotic substance which would be capable of exerting a bacteriostatic and bactericidal effect upon gram-negative and acid-fast bacteria has resulted in the development of streptomycin. This new antibiotic was reported in 1944 by Waksman and his associates<sup>1,2</sup> at the New Jersey Agricultural Experiment Station at Rutgers University as a result of work on the soil fungus, *Streptomyces* (*Actinomyces*) *griseus*. These workers observed that many substances isolated from the soil had antibacterial properties but the majority of them were also harmful to the cells of the body. However, some of these, particularly certain species of *Actinomyces*, did not produce substances which were markedly harmful to human cells and this fact stimulated interest which resulted in the preparation of the commercial form of streptomycin in increasing quantity.

**Properties.** Streptomycin is freely soluble in water thus permitting the preparation of the drug in small volumes and making it particularly adaptable for parenteral administration. It is insoluble in organic solvents.<sup>2</sup> This antibiotic has remarkably high stability both chemically and biologically not only in powdered state but also in solution. The drug in powder form may be kept at room temperature if refrigeration facilities are not available.

In contrast to penicillin, streptomycin is not influenced by enzymes associated with bacterial activity. Another difference between these two antibiotic agents is that streptomycin is a strong organic base, whereas penicillin is an acid. The maximum activity of streptomycin will be obtained in a pH of approximately 9.0 while penicillin will be most active at about pH 6.3 to 6.8.

**Absorption, Distribution and Excretion.** Streptomycin is similar to penicillin in its absorption and excretion, following administration, although the rate is considered to be somewhat slower.<sup>3,4</sup> The intermittent intramuscular route of administration is the one of choice for the maintenance of therapeutic blood levels.

As with penicillin, the drug does not pass known anatomical barriers, i.e., blood-brain, blood-pleura, blood-intestine; therefore, it is necessary to supplement its parenteral use with local administration. On the other hand, administered orally, streptomycin will provide high therapeutic concentration in the intestinal tract because of the absence of any destruction of the drug and nearly complete excretion in the feces. Inhalation by aerosol is a satisfactory means of introducing the drug into the tracheobronchial tree.<sup>5</sup>

Following parenteral administration, the drug is mobilized for excretion predominantly in the kidney and to a lesser degree in the bile. It has been recovered in peritoneal, pericardial and pleural fluids.

**In Vitro and In Viro Activity.** It is an established fact that the optimal antibiotic effects are obtained in the treatment of infections when the causal organism is proven to be susceptible *in vitro* to the therapeutic agent employed. In our studies<sup>6</sup> on streptomycin, it has been shown that a definite relationship exists between the susceptibility of the organism and the dosage of the drug necessary to produce effective concentrations. Correlation of such studies reveal that the mean blood serum level of 16 micrograms\* per cc. maintained by the intramuscular administration of 0.4 Gm. of streptomycin in

\* 1 microgram—: "S" unit.

4 cc. isotonic saline solution every four hours, resulted in the classification of gram-negative bacteria as follows:

Inhibition by 4 micrograms per cc. streptomycin—very sensitive

Inhibition by 16 micrograms per cc. streptomycin—sensitive

No Inhibition by 16 micrograms per cc. streptomycin—insensitive

No Inhibition by 128 micrograms per cc. streptomycin—resistant

In a specific appraisal of inhibition studies it is evident that streptomycin

is a common feature. The need for routine determinations of susceptibility of bacteria in conjunction with therapy is apparent.

Most strains of *Brucella melitensis*, *Eberthella typhosa*, *Escherichia coli*, *Hemophilus influenzae*, *Klebsiella pneumoniae* type A, *Neisseria*, *Pasteurella*, and *Shigella*, dysenteriae and paradysenteriae, are inhibited by 16 micrograms per cc. of streptomycin.

Resistant strains of bacteria are encountered among *Aerobacter aerogenes*, *Klebsiella pneumoniae* type B, *Proteus* and *Pseudomonas*. It may be assumed that

TABLE I

FACTORS INFLUENCING THERAPY WITH SULFONAMIDES, PENICILLIN, STREPTOMYCIN

	Sulfonamides	Penicillin	Streptomycin
Field of specific action.....	Both gram-positive and gram-negative bacteria	Many gram-positive organisms and important gram-negative cocci	Chiefly gram-negative but also certain gram-positive and acid-fast bacteria
<i>In vitro</i> action.....	Weak	Stronger than sulfonamides	Stronger than sulfonamides
Influence of number of bacteria.	Inhibited by large numbers	Minor effect	Minor effect
Effect of:			
Pus.....	Inactivated	Not appreciably inhibited	Not appreciably inhibited
Hydrolytic protein products	Inactivated	Not inhibited	Activity slightly diminished
Procaine.....	Inactivated	Not inhibited	
Other factors.....		Inactivated by penicillinase-producing bacteria	Inactivated by reducing substances; anaerobic conditions
Activity when parenterally administered.	Good but not usually so given	Good—usually so given	Good—always so given except for intraenteric lesions
Activity when orally administered.	Considerable	Requires 3 to 5 times parenteral dose	Limits activity to gastrointestinal tract
Development of sensitivity by patient.	Common	Less common than with sulfonamides	20 per cent
Potential toxicity.....	May be serious	Essentially non-toxic	Low as far as serious toxicity is concerned. Some effect on 8th nerve probably very common with prolonged dosage
Development of resistance by organism during treatment	Not infrequent	Uncommon	Frequent
pH most favorable to maximum activity.	pH not of any great consequence	6.3 to 6.8	9.0
Data on renal clearance.....	Important in relation to toxicity	Important in relation to absorption and excretion	Important in relation to toxicity

effectively inhibits the growth of a wide variety of aerobic gram-negative and gram-positive microorganisms. However, the range of sensitivity in both groups is wide, and considerable within-species variation

resistant members will be found in all groups when large numbers of strains have been checked.

Most aerobic sporulating gram-positive rods are very sensitive to streptomycin.

Attention is directed to *Bacillus anthracis*, four different strains having been found inhibited by 0.5 micrograms of streptomycin per cc.

Diphtheria bacilli are sensitive to streptomycin, while diphtheroids may be very sensitive or highly resistant.

Pneumococci are uniformly inhibited, regardless of serologic type. There is little difference in susceptibility between "S" (smooth) and "M" (mucoid) colony forms.

Staphylococci and streptococci exhibit a wide variation in sensitivity. Staphylococci show no distinction in their susceptibility to streptomycin irrespective of their coagulase or hemolytic properties. Streptococci in their susceptibility to streptomycin show no distinction as relates to their red cell reaction, or the serologic grouping of the hemolytic variety.

*In vivo* studies of streptomycin reveal that the drug is recovered from bile in one-fourth the concentration present in blood serum and that pericardial fluid, pleural transudate and ascitic fluid contain one-fourth to one-half of the blood serum level. Streptomycin does not diffuse readily from the blood stream into cerebrospinal fluid and therefore direct injections are required to obtain adequate concentrations. Streptomycin can be readily assayed in significant amounts from the kidney, liver, muscle and thyroid but it cannot be detected in lymph nodes, spleen, testes, brain, prostatic fluid and lung parenchyma. Only traces are found in the prostate and pancreas. Administered parenterally, streptomycin will not penetrate the walls of soft tissue abscesses although it is known that pus will not influence its activity.

*Comparison with Penicillin and Sulfonamides.* The practicing physician of today is confronted with the problem of choosing between streptomycin and other therapeutic agents, particularly penicillin and the sulfonamides. It seems desirable to be familiar with therapeutic agents, especially when they overlap as far as their sphere of activity in a given infection is concerned. Table 1 compares the factors

influencing the therapeutic potentialities of these three drugs.

As further evidence of variation in the therapeutic effect of streptomycin, penicillin and sulfonamides, the information which has accumulated relative to the susceptibility of organisms and the infections which they commonly cause is presented in Table II.

*Preparation and Administration.* Streptomycin is distributed commercially in 25 cc. vials containing the drug in 0.5 Gm. or 1.0 Gm. in powdered form. The powder dissolves readily in water or saline. The solutions should be stored under refrigeration but this need not apply to the powder. The dosage of streptomycin is usually referred to in terms of weight and the relationship of weight to units is as follows:<sup>2</sup>

1 Microgram—	1 "S" unit
1 Milligram —	1000 units or micrograms
1 Gram —	1,000,000 units or micrograms

Streptomycin can be prepared for clinical use in the form of solutions or ointments. Solutions are designated for either parenteral or local administration or for nebulization. The concentration commonly employed for parenteral use is a solution containing 0.1 Gm. per cc. For administration into the pleural cavity, the drug should be dissolved in as small a volume of saline as practicable. Solution in water or saline has been found satisfactory for giving the drug orally. It is entirely palatable, being tasteless and odorless.

For topical application, the drug may be incorporated in a water soluble or emulsion type of base in a concentration of 10 mg. per Gm. of base.

For nebulization, .05 Gm. of streptomycin should be dissolved in 1 cc. of solution.

For intrathecal injection, from .025 to .2 Gm. dissolved in 5 to 10 cc. of solution may be injected into the subarachnoid space every twenty-four hours.

*Clinical Indications and Usual Dosage.*<sup>7,8</sup> Streptomycin is now the preferred drug for

TABLE II

SUSCEPTIBILITY OF INFECTIOUS DISEASES TO TREATMENT WITH SULFONAMIDES,  
PENICILLIN AND STREPTOMYCIN

I. Etiology: Gram-negative Organisms							
Organisms	Sulfonamides	Penicillin	Streptomycin	Organisms	Sulfonamides	Penicillin	Streptomycin
<i>Aerobacter aerogenes</i> : cystitis, bacteremia.....	+	o	++	<i>Bacillus anthracis</i> : anthrax.....	+	++	S
<i>Brucella abortus</i> , <i>Brucella melitensis</i> : undulant fever (brucellosis).....	±	o	+	<i>Borrelia novyi</i> : relapsing fever..	S	++	S
<i>Eberthella typhi</i> : typhoid fever..	o	o	+	<i>Clostridium welchii</i> , septicum, etc.: gas gangrene.....	o	+	o
<i>Escherichia coli</i> (colon bacillus) meningitis, pyelonephritis, bacteremia, peritonitis.....	+	o	++	<i>Clostridium tetani</i> : tetanus.....	o	+	o
<i>Haemophilus ducreyi</i> : chancroid.....	++	o	++	<i>Corynebacterium diphtheriae</i> : diphtheria.....	o	+	S
<i>Haemophilus pertussis</i> : pertussis.....	o	o	S	<i>Leptospir</i> : leptospirosis (Weils disease).....	o	++	S
<i>Haemophilus influenzae</i> : influenza meningitis.....	+	o	++	<i>Mycobacterium tuberculosis</i> : tuberculosis-miliary, renal, lupus erythematosus.....	o	o	+
<i>Klebsiella pneumoniae</i> : Friedländer's infections—pneumonia, meningitis otitis, cystitis.....	+	o	++	<i>Pneumococcus</i> : empyema, endocarditis mastoiditis, meningitis, peritonitis, pneumonia.....	++	++	++
<i>Neisseria gonorrhoeae</i> : gonococcus infections—arthritis, endocarditis, gonorrhea, meningitis, ophthalmia.....	++?	++	++	<i>Staphylococcus</i> : abscesses and carbuncle, arthritis, endocarditis, osteomyelitis, pneumonia, wound infections.....	±	++	+
<i>Neisseria intracellularis</i> : meningococcus bacteremia, meningitis.....	++	++	S	<i>Spirillum minus</i> , streptobacillus monilli formis: ratbite fever..	o	++	?
<i>Pasteurella pestis</i> : plague.....	+	o	S	<i>Streptococcus hemolytic-beta</i> : empyema, erysipelas, mastoiditis, peritonitis, pneumonia, scarlet fever, tonsillitis, endocarditis, wound infections.....	++	++	+
<i>Pasteurella tularensis</i> : tularemia.....	±	o	++	<i>Streptococci</i> : anaerobic.....	o	++	?
<i>Proteus vulgaris</i> : otitis, meningitis, pyelonephritis, bacteremia.....	+	o	++	<i>Streptococcus viridans</i> : endocarditis.....	±	++	+
<i>Pseudomonas aeruginosa</i> : pyocyanus infections.....	±	o	+	<i>Streptococcus non-hemolytic</i> : (enterococcus-urinary infections).....	o	o	+
Enteriditis paratyphoid and other <i>Salmonella</i> .....	±	o	+	<i>T. pallida</i> : syphilis.....	o	++	S
<i>Shigella dysenteriae</i> , bacillary dysentery, acute.....	++	o	++	<i>T. pertenue</i> : yaws.....	o	++	?
<i>Vibrio cholera</i> : cholera.....	o	o	S				
II. Etiology: Gram-positive Organisms							
<i>Actinomyces bovis</i> : actinomycosis.....	+	++	+				

\* With antitoxin therapy.

o—No response

+-Inconstant response

±—Doubtful benefit

++—Drug of choice

S—Organisms susceptible, but use of drug not clinically established.

certain heretofore unconquerable gram-negative and acid-fast bacterial infections. It has also proved to be of considerable value in the treatment of infections caused by certain gram-positive organisms which are resistant to penicillin and sulfonamides and those which attack patients manifesting sensitivity to either or both of these drugs.

The following are illustrative of various types of infections which, in our experience, have shown various degrees of response to streptomycin:

*Genitourinary Infections.* Maximum results are obtained when (1) the urinary flow is unobstructed and kidney function is adequate and (2) the bacteria are sensitive to the drug. The dose is 1.5 to 2 Gm.

daily for five days by the intramuscular route. It is important to remember streptomycin is a valuable aid to urological surgery but it does not substitute for such surgery. Non-sterilizable foci such as calculi and abscesses must be managed in the usual manner. For uncomplicated gonorrheal urethritis in the male, streptomycin is indicated in doses of 0.5 Gm. intramuscularly every three to four hours for six to eight doses. Despite the fact that streptomycin has been effective in the treatment of gonorrhea, penicillin is still considered the drug of choice.

*Bacteremia, Including Endocarditis.* The excellent results for the use of penicillin are duplicated with streptomycin provided: (1) The organisms are susceptible; (2) the dosage and duration of treatment are adequate; (3) surgical management of the lesion from which the bacteremia arises is early and exact, and (4) adequate attention is given to the management of the patient as a whole.

A daily dose of 2 to 4 Gm. of streptomycin given at four-hour intervals for approximately two weeks is usually adequate. For gram-positive coccal bacteremias, particularly due to streptococcus viridans of the enterococcus group, it may be advantageous to combine streptomycin with penicillin. Experience has shown that these two antibiotics are compatible and therefore may be given in the same syringe.

*Meningitis.* Streptomycin diffuses poorly into the cerebrospinal circulation from the blood stream and therefore the drug must be given by direct instillation in order to complement parenteral administration. The usual adult dosage employed is 100 mg. dissolved in from 5 to 10 cc. of isotonic sterile saline or non-purulent cerebrospinal fluid administered intrathecally one or twice daily. The dosage for children is proportionately smaller, both intrathecally and parenterally. The drug is indicated in all cases of gram-negative bacterial meningitis.

*Ear Infections, Including Otitis Externa, Otitis Media, Mastoiditis and Complicating*

*Solitary Brain Abscess.* In the treatment of these conditions, the accepted surgical principles must be followed exactly in order to establish optimum conditions for chemotherapy. Parenteral administration of the drug must be supplemented by surface or local instillations of solutions to secure therapeutically effective levels.

*Infections of the Gastrointestinal Tract.* Bacillary dysentery due to *Shigella* organisms has responded exceedingly well to streptomycin, especially the acute form of the disease. Experience has demonstrated that streptomycin has been highly effective in cases of bacillary dysentery which have not responded to sulfonamide therapy. The drug has not been found to be of value in the amoebic form of dysentery. Such conditions as non-specific idiopathic ulcerative colitis, enterocolitis and regional ileitis are not satisfactory conditions for the use of streptomycin, although occasionally they may be benefitted temporarily. Typhoid and paratyphoid fever, up to the present time, have not been satisfactorily influenced by streptomycin.

*Peritonitis.* Although results of streptomycin in this condition have not been spectacular, beneficial effects have been observed following doses of 3 to 4 Gm. per day administered intramuscularly in early spreading peritonitis.

*Cholangitis and Liver Abscess.* The main problem associated with the treatment of these conditions relates to information concerning sensitivity of the causative organism. No large series of streptomycin-treated cases have accumulated, but such therapy is desirable on a trial basis. Knowledge that only one-quarter of the blood serum level is present in the bile dictates that the drug should be employed in a minimum daily parenteral dosage of 3 to 4 Gm. The suggested use of the T-tube for providing the drug in sufficient concentration in the biliary system demands further evaluation.

*Preoperative Preparation of the Intestinal Tract.* The potent sterilizing effect of streptomycin on susceptible bacteria is

invaluable for preoperative preparation of the intestinal tract. The drug should be given orally in doses of 1 Gm. every eight hours three to four days prior to resection.

*Pneumonia, Empyema and Lung Abscess.* These conditions when caused by susceptible gram-negative organisms, especially Friedländer's bacilli, are benefitted by streptomycin administered systematically as well as by instillation into the pleural cavity. The supplementary use of streptomycin by aerosol therapy is indicated in the preparation for surgery of the patient with pulmonary suppuration due to organisms susceptible to the drug.

*Tularemia.* This condition, including the typhoidal, glandular, oculoglandular and ulcerative glandular types, is best effected early in the course of the infection. The dose of 1 to 3 Gm. administered daily by the parenteral route for five to ten days has provided very satisfactory results.

*Brucellosis.* Recent experience which has accumulated indicates that streptomycin supplemented by sulfonamide therapy is worthy of further trial in the acute or bacteremic form of brucellosis. Best results have been obtained with a daily dosage of 3 Gm. of streptomycin parenterally and 6 Gm. of sulfadiazine orally for a period of at least twenty-one days.

*Tuberculosis.* Early experimentation with streptomycin in laboratory animals indicated that the drug has a definite suppressive effect on the infection. Current investigations in clinical cases of tuberculosis reveals that prolonged courses of therapy are necessary to bring about a like effect. The most favorable effects are obtained in the exudative forms of the disease. The drug appears to be of value as an adjuvant to surgery associated with tuberculosis to minimize seeding of the tubercle bacilli. An average parenteral daily dose is 1.5 Gm.

*Wound Infections.* Streptomycin occupies a place similar to penicillin in the surgical management of wound infections. To be effective, streptomycin, both paren-

terally and topically, must be used in conjunction with surgery so that all foci of the infection are reached.

Streptomycin is not indicated in tetanus, botulism, gas gangrene, malaria, typhus, fungus diseases, spirochetal infections and virus infections.

*Untoward Reactions.* Pain and irritation at the site of injection are fairly common and changing of these sites is recommended. Cutaneous eruptions and urticaria accompanied by fever may be encountered but prompt remission follows withdrawal of the drug. Occasionally, the reaction may be manifest by headache, circumoral tingling, transient dizziness, arthralgia and myalgia. Some of these symptoms disappear in spite of continuation of therapy. If the effects are severe, the drug should be discontinued.

Irritation of the kidneys, as indicated by the appearance of albumin and casts in the urine, can be observed. Except where protracted courses of streptomycin are necessary, e.g., tuberculosis, this effect is transient. Because of this possibility renal function should be tested previous to and during use of the drug.

Otitic manifestations of toxicity do occur in certain individuals if the treatment is continued two weeks. The vestibular portion of the eighth nerve is most usually affected and dizziness on change of position is the most outstanding symptom. Examination reveals no response to the introduction of ice water into the auditory canal. Occasionally, patients show a positive Romberg or nystagmus. Audiogram tests may reveal subclinical deafness. Fortunately, the optic nerve assumes the gyroscopic function of the vestibular nerve and the patient gradually compensates for and recovers from his symptoms. Where damage to the eighth nerve is demonstrated as due to streptomycin further therapy is contraindicated.

#### SUMMARY

1. The recently developed antibiotic, streptomycin, provides a new therapeutic

aid for the control of organisms usually unaffected in the same degree by penicillin and sulfonamides.

2. A table showing the comparison of streptomycin with penicillin and sulfonamides is presented.

3. Streptomycin is prepared for administration in a manner similar to penicillin but dosage is expressed in terms of weight rather than in units.

4. The routes of administration are the same as in the case of penicillin except oral administration of streptomycin is suitable only for the treatment of intraenteric conditions.

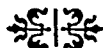
5. Listings of the current indications for the drug with suggested dosages are made.

6. Streptomycin is not devoid of toxic effects although these for the most part are not serious when the course of therapy does not exceed two weeks. Untoward effects on the eighth cranial nerve contraindicate further streptomycin therapy.

7. The exact clinical status of the drug in several conditions must still be defined.

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# CROSSED ECTOPIA WITH FUSION\*

## REVIEW OF LITERATURE AND A REPORT OF FOUR CASES

BENJAMIN S. ABESHOUSE, M.D.

FUSION anomalies of the kidney are the most interesting and intriguing subjects in urology. It has attracted the attention of anatomists, pathologists, embryologists, and urologists for many years. One of the relatively rare types of renal fusion anomalies is crossed ectopia with fusion. The author is cognizant of the intrinsic value of a report of four cases but believes there is further justification for an additional contribution to the literature in the fact that this anomaly presents unusual problems in diagnosis and treatment. Excellent contributions to this subject have been made by Gerard (1905), Pierson (1909), Stein (1916), Kretschmer (1925), Pierson (1932), Townsend and Frumken (1937), and Wilmer (1938). In the preparation of this paper the author has drawn extensively from the observations of these contributors.

*Terminology.* Since this anomaly presents considerable variations in the size, shape and position of the fused renal components, a multiplicity of descriptive terms have been used to designate this anomaly. Not infrequently a specific term has been employed to describe several variations or different terms have been used interchangeably which has caused confusion and misunderstanding.

Until quite recently, the term, unilateral fused kidney, has enjoyed great popularity. It soon became apparent that this term was rather ambiguous because it was easily confused with other unilateral renal anomalies, viz. (1) congenital solitary kidney (unilateral aplasia) with a normal kidney and ureter and (2) congenital solitary kidney of the double or fused supernumerary type with partial or complete duplication of the ureter. Furthermore, the two renal components of crossed

ectopia with fusion are not always definitely located on the same side of the body as in the prevertebral or pelvic type. Consequently the term, crossed ectopia with fusion, has been adopted almost universally inasmuch as it more accurately fulfills etymological, embryological and anatomical requirements.

*Definition.* The distinguishing features of crossed ectopia with fusion is the congenital transposition of one kidney to the opposite side with fusion of one kidney to the other, usually the lower pole of the superior kidney to the upper pole of the inferior crossed ectopic kidney. The area and extent of the fusion, the location of the fused renal mass, the length, thickness and structure of the isthmus, and the relation of the renal axes to each other may exhibit considerable variability.

*Anatomical Forms.* The various types of crossed ectopia with fusion may be classified according to size and shape of the fused renal mass. The most common types are indicated in Figure 1. A brief discussion of each type is warranted:

*Unilateral Fused Kidney (with Ectopic Kidney in Inferior Position).* This is the most common type encountered. It has also been designated as unilateral elongated kidney, *ren elongatus simplex*, *symphysis renale unilaterale*, *rein ectopique croise*, *rein allonge* and *langen niere*. The characteristic feature is the pole to pole fusion. The crossed ectopic kidney is always inferior and its upper pole is fused to the lower pole of the superior kidney. Axial rotation of both kidneys is present with the result that both pelves and hili are usually situated anteriorly and directed toward the midline. The ureter of the superior kidney enters the bladder on the same side, while the ureter from the inferior

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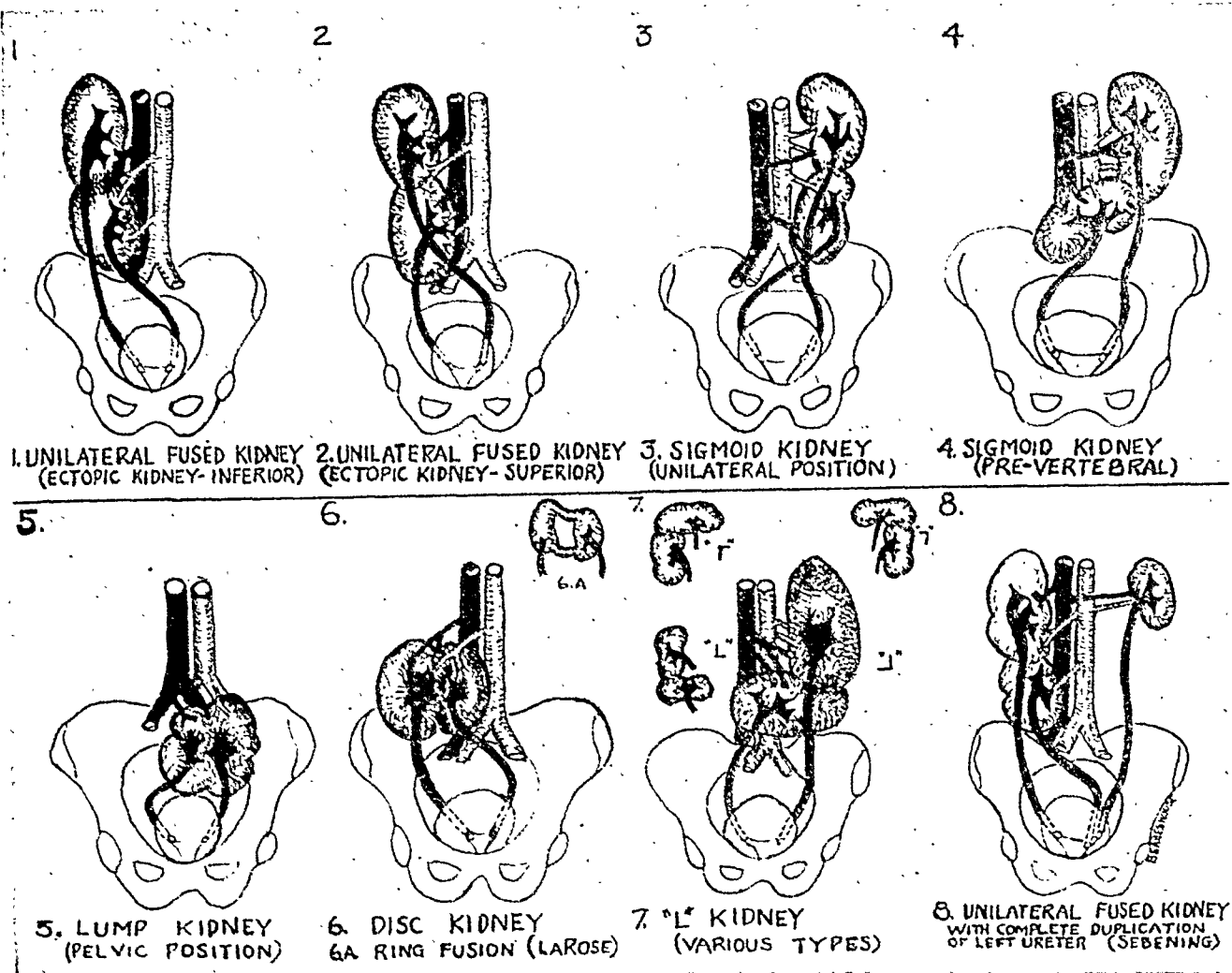


FIG. 1. Diagram illustrating the different types of crossed ectopia with fusion.

ectopic kidney crosses the midline and enters the bladder on the opposite side in its normal position in the trigone.

Sebening reported a unique case of a right unilateral fused kidney with the ureter of the lower crossed ectopic kidney crossing the midline to enter the bladder on the left and a separate left ureter leading to a small atrophic left kidney in its normal lumbar position.

**Sigmoid Kidney.** This type is next in frequency. It is also known as "S" shape, sigma-niere and ren sigmoideus as originally proposed by Broesiker. The characteristic feature is also pole to pole fusion which occurs after each kidney has completed its axial rotation. Consequently the upper pole of the inferior ectopic kidney is fused to the lower pole of the superior kidney but the convex borders of the two kidneys are pointed in opposite direc-

tions. Thus the fused mass assumes an "S" shape. The ureters from each kidney enter the trigone in the same manner as in the previous type. This type of kidney anomaly has been reported by several writers.<sup>39,64,90,113</sup>

**Lump Kidney.** This is a relatively uncommon type. It is also described as clump kidney, cake kidney, kuchen niere, ren fungiformis and ren informis. The characteristic feature is the extensive fusion of the two kidneys over a greater area than in the two previous types. The fused renal mass is composed of irregular lobules of different sizes and is usually situated at or above the sacral promontory. The outline of each kidney often cannot be made out and consequently the fused mass has been mistaken for a congenital solitary kidney. The ureters are anterior and short. The blood supply

usually enters the upper margin of the mass but may enter on the anterior or posterior surface between the lobules. The distinguishing feature is the fact that the ureter of the ectopic component crosses the midline to enter the bladder in its normal position. This type of kidney has been reported by several writers.<sup>7,64,79,83</sup> In some cases of "lump" kidneys, particularly the prevertebral or pelvic types, the unilaterality of the fused mass is not distinctive as each renal segment appears to be situated on the side it normally belongs.

*Disc, Discoid or Shield-shape Kidney.* This is a rare type of crossed ectopia with fusion which has been also designated as doughnut kidney, scutiform kidney, rien en galette, rien en gateau, rien ectopique, croise concrent, ren concretus and ren scutaneus. In this type both kidneys are situated on the same level, i.e., at or slightly above the sacral promontory. Fusion usually occurs along the entire length of the medial borders of each kidney and the pelves are directed anteriorly. The ureter of the ectopic kidney crosses the midline to enter the bladder at its normal opening. The discoid type of crossed ectopia with fusion have been reported by several writers.<sup>7,36,52,57</sup> LaRose and Bourgeois have observed an extremely rare type with fusion in the form of a "ring."

*"L" Kidney.* This is an uncommon type which has been described as rein en "L" and ren uncinatus. Some observers consider it to be a transitional form between the unilateral fused kidney and horseshoe kidney. The fusion usually occurs between the median aspect of the lower pole of the superior kidney and the cephalad pole of the inferior crossed ectopic kidney. The superior kidney is larger and maintains its vertical position with its pelvis directed anteriorly. The ectopic kidney is smaller and lies transversely with its long axis perpendicular to the superior kidney and its pelvis facing anteriorly. This type of case has been

reported by several writers.<sup>44,68,89,104</sup> The fused mass resembles the capital letter "L." In an occasional case, the position of the renal components may be inverted or reversed.

*Unilateral Fused Kidney (with Ectopic Kidney in Superior Position).* This is a very rare type of crossed ectopia with fusion in which the position of the two renal components is reversed. The axial rotation and course of the ureters is the same as in the previous type. The crossed ectopic kidney occupied the superior position in only sixteen of the 337 cases reviewed by the author.<sup>17,35,40,46,50,51,54,57,73,76,78,87,92,96,102,110</sup>

*Location.* The crossed ectopic kidney with fusion has been found at various levels from the lower thoracic vertebrae to a position deep in the true pelvis. Stewart and Lodge have proposed a classification of the various types of this anomaly based on their position, namely, (1) prevertebral fused portion of the crossed ectopic kidney lying over the vertebrae, (2) unilateral fused; the entire renal mass lies on one side of the body, lateral to the vertebrae, and (3) pelvic fused; the entire renal mass lies within the true pelvis.

*Structural Changes.* The renal components may show remarkable variations in size and shape. The outline of each kidney is preserved for the most part in the simpler fusion types, i.e., unilateral elongated and sigmoid kidneys. Marked irregularities in the outline are noted in the more complex types: "L" kidney, lump kidney and disc kidney. Fetal lobulations are more commonly observed in the latter types.

Studies of the weight and measurements of the combined renal mass have been made by Papin and Palazzoli and Wilmer. Papin and Palazzoli reviewed ten cases and found that the weight of the fused kidneys was less than the normal weight of two normal kidneys (270 Gm.) in five cases and equal or superior in five cases. Wilmer reported the average weight

of seven fused kidneys in adults as 314 Gm. One would naturally expect to find extensive variations in the measurements of the various types of fused kidneys. As a rule, the length of the combined kidney mass is always greater than the normal kidney (12 cm.) but rarely exceeds 20 cm. Wilmer found the average length to be 16.8 cm. (seventeen cases), width 7.6 cm. (fourteen cases), and thickness 4.1 cm. (seven cases).

*Vascular Supply.* The normal kidney derives its blood supply from the aorta. Felix and Brasch have drawn an analogy between the ascent of the permanent kidney through the mesonephric arteries and the climbing of an arterial ladder. When the upward migration of the kidney is halted for any reason, the cephalad arteries persist and the caudal vessels undergo regression and disappear.

In the case of crossed ectopia with fusion, both renal components develop an abnormal blood supply. The number and origin of the vessels are dependent upon the position of fused kidneys. Papin and Palazzoli found the arteries derived from the upper abdominal portion of the aorta in thirty-three of forty-eight cases, and from the lower portion of the aorta and common iliac in twelve cases. The number of arteries may vary from one to six but from two to four were found in the majority of cases (thirty-five of forty-eight cases). In the unilateral fused kidney, the superior kidney usually receives one or two arteries from the abdominal aorta and the inferior ectopic kidney receives one or more arteries from the lower aorta or common iliac artery, depending upon the location of the kidney.

*Ureters.* The usual anatomical course of the ureters in this anomaly has already been described. Various anatomical and pathological abnormalities of the ureters have been reported and are listed in Table 1.

*Embryology.* A knowledge of the more pertinent facts concerning the development of the normal kidney is essential to an understanding of the true nature of

this abnormally fused kidney. Three sets of urinary excretory organs appear in the embryo. The first or primitive kidney is called the pronephros and disappears completely at a very early stage. This is followed by a second excretory organ known as the mesonephros which is developed from the cephalad end of the undifferentiated cell mass lying medial to the Wolffian duct. The mesonephros undergoes rapid retrogression as the third and permanent kidney, known as the metanephros, develops.

TABLE I  
ANATOMICAL AND PATHOLOGICAL ABNORMALITIES  
OF THE URETERS

Condition	No. of Cases
1. Stricture.....	5
2. Obstruction.....	6
3. Dilatation	
(a) Congenital idiopathic.....	1
(b) Acquired.....	3
4. Kink.....	3
5. Both ureters crossing each other.....	14
6. Both ureters crossing midline.....	1
7. Two ureteral orifices on one side, one orifice on the other side <sup>31</sup> .....	1
8. Ectopic ureteral orifice	
(a) Bladder <sup>47,63,81,95</sup> .....	4
(b) Prostatic urethra <sup>48,110</sup> .....	2
(c) Uterus <sup>36</sup> .....	1
9. Imperforate orifice.....	1
10. Bifurcation (incomplete duplication)	
(a) Unilateral.....	5
(b) Bilateral.....	2
11. Pelvic (calyceal abnormalities)	
(a) 5 calyces with 1 ureter.....	2
(b) 4 calyces with 1 ureter.....	3
(c) 3 calyces with 1 ureter.....	4
(d) 1 pelvis with 3 ureters.....	1
12. Communication between pelvis and calyces of both kidneys <sup>96</sup> .....	1
13. Stone.....	3
14. Papilloma <sup>8</sup> .....	1
15. Scrotal herniation of ureter <sup>11</sup> .....	1
16. Tuberculosis of ureter <sup>22</sup> .....	1
Total.....	66 cases

At first the pronephric duct is composed of a solid cylindrical mass of cells of mesodermal origin and later, in 7 mm. stage, it becomes hollow when it is known as the primary excretory duct (Wolffian duct). About the twenty-sixth day of embryonic life (5 mm. embryo), the ureteric bud appears as an outgrowth on

the dorsal surface of the Wolffian duct near its caudal termination. At this stage the bud is directed posteriorly toward the vertebral column and develops as a narrow stalk, i.e., future ureter, with a blind expanded end which becomes the future pelvis. From this blind end, there develop cranial and caudal diverticula which give rise to the future calyces and collecting tubules. At the 8 mm. stage, the ureteric bud shifts laterally to the dorsolateral aspect of the Wolffian duct.

The cephalad end of each ureteric bud is surrounded by the metanephric blastoma which is derived from the caudal end of the undifferentiated mesodermal cell mass of the Wolffian body. The metanephric blastoma is composed of (1) an inner zone of closely packed cells with numerous mitoses which subsequently form the glomeruli and tubules and (2) an outer zone of loosely packed cells which give rise to the capsule and connective tissue of the kidney.

The extreme caudal portion of the Wolffian duct, i.e., the portion extending from the ureteric bud to the cloacal opening of the duct, is drawn out in a rolling process and absorbed into that portion of the urogenital sinus (vesico-urethral anlagen) which later forms the trigone of the bladder. From the remainder of the caudal ends of the Wolffian ducts in the male are derived the ejaculatory ducts, seminal vesicles and vas deferens. In the female the extreme caudal end of the Wolffian duct persists as a series of radiation tubules (i.e., vestigial epophoron) between the ovary and the obliterated end of the Wolffian duct. The adjoining portion of the caudal end of the duct persists as an embryonic remnant known as Gaertner's duct.

The upward migration of the permanent kidney is more relative than actual and involves three components: ascent, rotation and axial deflection. In the 7 mm. embryo, the permanent kidneys are represented by two caudally situated masses of nephrogenic tissue which lie close to each

other but are completely separated. As the body grows in its crown-rump length, there is a straightening of the back and a development of the pelvic curvature with a concomitant increase in the length of the ureter. The lengthening of the ureter results in a relative change in the position of the permanent kidney from a pelvic to a lumbar organ. With this change in position there is a 90 degree lateral rotation of the kidney on its long axis with axial deflection of the pelvis in a medial direction. As a result of these changes the hilus is directed medially whereas originally it pointed anteriorly. These changes are completed by the end of the second embryonic month (26 to 28 mm. embryo).

It is readily apparent from the complex embryonic development of the kidneys and ureters that the chain of events in the formation of these structures may be broken at any stage with a resultant abnormality of number, form, position or structure, singly or in multiple combinations. While it may be difficult to determine the mechanical factors responsible for development of some renal anomalies, one can predict with some degree of accuracy the time when these anomalies are produced. Inasmuch as an anomalous bloody supply is a natural consequence of congenital renal anomaly of form and position, it also serves as an indication of the stage at which the anomaly develops. Thus one can assume that crossed ectopia with fusion occurs at about the 8 mm. stage, i.e., before the permanent kidney has ascended out of the true pelvis. This view is substantiated by other embryological evidence.

The development of the various fusion anomalies is undoubtedly influenced by several factors of primary or secondary importance, i.e., disturbances in the size, position, growth and rotation of the ureteric bud, an obstruction to the ascent of the kidney by vascular barriers, or abnormal vascularization of the kidneys *per se*. Any of these factors may alter the anatomic relations of the metanephric

blastema in such a manner that fibrous adhesion or fusion of two kidneys occurs.

The fusion anomalies probably occur between about the 5 and 8 mm. stage when the metanephric blastemas surrounding the cephalad ends of the ureteric bud are situated within the true pelvis and are in close proximity to each other. When fusion occurs between the outer zones of the metanephric blastema, a fibrous connective tissue union or isthmus is produced. When the fusion process is more extensive and involves the inner zone of cells, as it most commonly does, the union is composed of active renal tissue. Inasmuch as the lower ends of the metanephric blastemas are in closer proximity than the upper ends, the most common form of fusion is a union of the kidney by their lower poles, i.e., horseshoe kidney.

The exact factors involved in the development of crossed ectopia with fusion have not been definitely established. Various interesting theories have been proposed to explain the irregular and bizarre types of fusion associated with this anomaly:

1. Faulty development of the ureteric buds
  - (a) Abnormal location of the buds<sup>73,97</sup>
  - (b) Inequality in growth rate<sup>58,97</sup>
  - (c) Abnormal direction of growth<sup>88</sup>
  - (d) Faulty rotation<sup>75</sup>
- II. Vascular obstruction to the ascent of the permanent kidneys
  - (a) Inherent arterial barrier
    - (1) Bifurcation of aorta<sup>69</sup>
    - (2) Inferior mesenteric arteries<sup>75,84</sup>
    - (3) Umbilical arteries<sup>47</sup>
  - (b) Abnormal vascularization of kidney, *per se*<sup>44,55</sup>
- III. Environmental factors
  - (a) Rotation of intestines<sup>88</sup>
  - (b) Descent of sex glands<sup>88</sup>
  - (c) Abnormal enlargement of caudal end of Wolffian duct<sup>88</sup>
  - (d) Mechanical defects in fetal pelvis or its contents<sup>1</sup>
  - (e) Absence of loose mesenchymal tissue on dorsal aspect of nephrogenic cord<sup>1</sup>

- (f) Medial displacement of kidney by compact mesoderm<sup>1</sup>

A critical evaluation of these factors discloses the primary significance of faulty development of the ureteric buds in the production of adhesion or fusion of the metanephric blastemas. Most authors are in accord concerning the fundamental rôle of the "organising effect" of the ureteric bud in production of fusion anomalies. Other factors may have influence on the proper differentiation and growth of the ureteric bud and metanephric blastemas. Mayer has stressed the rôle of the abnormal direction of the growth of the ureteric bud in the development of one type of unilateral fused kidney. This is exemplified by the growth of one ureteric bud into the metanephric blastema of the opposite side while the blastema on the same side fails to develop. According to Felix and Schreiner, an inequality in the growth rate of the two buds may be an important factor in the development of fusion anomalies. They maintain that not infrequently one kidney is apparently in advance of the other with a tendency of the left kidney to lead. Thus it is possible that as the most advanced kidney passes over the umbilical artery from the true pelvis to the false pelvis, it lies almost horizontally and its lower pole may come in contact with the upper pole of the less advanced kidney which lies within the true pelvis. Joly, Foley and Wilmer maintain that fusion between dissimilar poles occurs at this stage in the above manner. On the other hand, Carleton is of the opinion that fusion between dissimilar poles occurs as a result of unusually high degree of differentiation in the growth rate of the ureteric diverticula. Joly believed that fusion of similar poles occurs in early stages due to abnormal contact of the lower poles which are in close proximity whereas fusion of dissimilar poles occurs at a later stage. The latter statement does not explain the bizarre and irregular fusion anomalies found within the true pelvis. It is apparent that some fusion anomalies occur before

TABLE II  
ALPHABETICAL TABULATION OF 51 CASES COLLECTED BY THE AUTHOR

Case No.	Author	Year	Sex	Age	Side	Method of Diagnosis				Symptomatology				Clinical Diagnosis	Operation	Result	Associated Pathology	Remarks
						Autopsy	Retrograde Pyelography	Intravenous Urography	Operation	Pain	Mass	G.U. Symptoms	Other Symptoms					
1	Abeshouse	1946	M	33	R	..	X	.....	..	X	X	Hematuria	Nausea	Chronic appendicitis	Pyelolithotomy	R	Calculus in ectopic kidney (middle calyx)	8 normal pregnancies
2	Abeshouse	1946	F	77	R	..	X	.....	..	X	X	Pyuria Urgency Frequency	Fever	.....	.....	.....	Acute pyelonephritis	3 normal pregnancies Hosving's sign, positive
3	Abeshouse	1946	F	45	L	..	X	Unsatisfactory	..	X	..	Urgency Frequency	.....	.....	.....	.....	Left ectopic kidney, superior Left ureter opening in uterus	Cong. kyphoscoliosis Cong. atresia of vagina Died, bronchopneumonia
4	Abeshouse	1946	F	13 mos.	R	X	.....	.....	..	..	..	Incontinence	.....	.....	.....	.....	Cong. stricture of lt. ureter Cong. vesico-vaginal fistula Cong. absence of lt. adrenal	
5	Appajee & Pittamma	1942	F	35	L	X	.....	.....	..	X	X	Dysuria	.....	Acute pyelonephritis	.....	.....	Pyelitis; pyonephrosis	
6	Ayzenstein	1937	F	48	R	..	.....	.....	..	X	..	.....	.....	Acute pyonephrosis	.....	.....	Renal abscess Dilatation of ureter	Nephritis previously
7	Bazemore & Gelson	1939	F	Adult	R	..	X	Cheek	..	X	..	Albuminuria	Nausea	.....	.....	.....	.....	
8	Beeg	1938	M	31	L	..	Cheek	X	..	..	..	Albuminuria	Vomiting	.....	.....	.....	.....	
9	Benvenuti	1946	M	22	L	..	X	.....	..	..	X	Pyuria	Epigastric disc Edema & inflammation of eyelids	.....	.....	.....	.....	
10	Bourgeois	1938	M	28	R	..	.....	X	..	X	X	.....	.....	Floating kidney	.....	.....	.....	
11	Bourgeois	1938	F	33	R	..	.....	.....	..	..	..	.....	.....	.....	.....	.....	.....	Supernumerary lt. thumb Cong. syphilis, Pneumonia
	Campbell	1937	M	7 wks.	L	X	.....	.....	..	..	..	.....	.....	.....	.....	.....	.....	
	Campbell	1937	M	Pre-mature	R	X	.....	.....	..	..	..	Pyuria	.....	.....	.....	.....	.....	
	Campbell	1937	F	8	R	..	X	.....	..	X	..	.....	.....	.....	.....	.....	.....	
	Campbell	1937	M	19	L	..	X	.....	..	..	X	.....	.....	.....	.....	.....	.....	

[illegible]



TABLE II(Continued)

Case No.	Author	Year	Sex	Age	Side	Method of Diagnosis				Symptomatology				Clinical Diagnosis	Operation	Result	Associated Pathology	Remarks
						Autopsy	Retrograde Pyelography	Intravenous Urography	Operation	Pain	Mass	G.U. Symptoms	Other Symptoms					
31	Nation	1915	F	24	R	..	×	..	..	..	..	..	..	..	..	..	Chronic glomerular nephritis	
32	Nation	1915	F	7	L	×	..	..	..	..	..	Pyuria	..	..	..	R	Hydronephrosis (ectopic kidney)	
33	Nation	1915	M	7	R	×	×	Unsatisfactory	..	×	..	Pyuria	..	..	Heminephrectomy (ectopic kidney)	..	Atrophy of ectopic kidney	
34	Nichols	1915	F	25	R	..	×	..	..	×	×	..	..	..	Nephropexy (entire fused kidney)	R	..	3 normal pregnancies
35	Parin	1938	F	26	R	..	×	..	..	..	..	Frequency	..	..	1. Heminephrectomy (superior kidney)	R	Hydronephrosis bilat.	* 3 yrs. later
36	Pearlman & Harwood	1946	M	47	R	..	×	..	..	..	..	Dysuria	..	..	2. Uretero-cutaneous implantation*	..	Pyonephrosis (non-ectopic kidney)	
37	Pearson & Honke	1941	F	58	R	..	×	Check	..	..	..	Pyuria	..	..	Ligation of aberrant blood vessel	..	Bilateral partial duplication of ureters	
38	Reay	1938	M	45	R	..	Check	×	..	..	..	..	..	..	..	R	Hydronephrosis of pelvis of ectopic kidney due to aberrant blood vessel	3 previous abdominal operations, no relief
39	Richard	1939	M	29	L	..	Check	×	..	×	×	Pyuria	Nausea Vomiting	..	..	..	..	
40	Scalfi & Silani	1940	F	16	R	..	×	Unsatisfactory	..	..	..	..	..	..	Exploratory laparotomy	R	2 lt. ureters (one crossed to inferior ectopic kidney)	
41	Selbring	1930	F	13	R	..	×	..	..	×	×	..	..	Mesenteric tumor	..	..	1 rt. ureter	
42	Silica & Brown	1937	M	37	R	..	×	..	..	×	×	Albuminuria	..	..	..	..	Rt. ureteral stricture	
43	Takakashi & Iwashita	1910	F	21	R	..	×	..	×	..	..	..	Diarrhea	..	..	..	Acute pyelitis	
44	Williams	1913	F	7	R	..	Check	..	..	..	..	Pyuria	..	..	Exploratory laparotomy	R	Hydronephrosis of non-ectopic kidney	
45	Winabury-White	1910	M	48	R	..	×	Unsatisfactory	..	×	..	Hematuria	..	..	..	..	..	

ascent of the kidneys out of the pelvis and others occur after the kidneys have left the true pelvis.

Vascular obstruction to the ascent of the permanent kidneys probably plays a secondary rôle in the development of fusion anomalies of the kidneys for its influence presumably is exerted after fusion of the kidneys in their pelvic position has taken place. However, some investigators attach a primary etiologic rôle to this factor on the ground that the arterial barrier not only serves as a mechanical obstruction to the ascent of the kidneys in the proper direction but also tends to bring the two permanent kidneys closer together.

The rôle of the arterial barrier in arresting or interfering with the ascent of the fused renal mass associated with simple or complex fusion anomalies has not been definitely established. The author is of the opinion that the arterial crotch formed by the bifurcation of the aorta at the pelvic rim possesses more theoretical than factual significance as a mechanical obstruction to the ascent of the permanent kidney. More credence can be attached to the rôle of the umbilical artery as a vascular barrier as emphasized by Carleton. The umbilical artery arises by multiple roots, i.e., one ventral and two lateral, which form an arterial ring around the Wolffian body. The unusual persistence of this ring or of a lateral root might conceivably hold up the lateral swing of the ureteric bud but is more likely to interfere with the upward migration of the normal or fused kidney. The same applies to the inferior mesenteric artery. Any intrinsic or extrinsic factor which interferes with the degeneration or regression of the blood vessels supplying one or both permanent kidneys may result in abnormal fixation, displacement or fusion of the involved organ.

The difficulties in ascent of the fused kidneys appear directly proportional to the extent of the fusion of the two kidneys. In the case of the simple fusion of the

lower poles, i.e., horseshoe kidney the, developing renal masses are permitted to grow on either side of the midline with slight interference to their ascent to a high lumbar level. The large irregular kidney mass resulting from the complex fusion associated with crossed ectopia encounters greater difficulty in its upward migration. The lump kidney with its totally irregular and complex fusion and the disc kidney with its extensive fusion of the medial borders of two kidneys are usually found within the true pelvis and rarely above the promontory of the sacrum. The ascent of simpler forms of crossed ectopia with fusion, i.e., unilateral fused kidney and sigmoid kidney, is interfered with to a lesser degree for they manage to reach the lower lumbar vertebrae.

In the case of simpler forms of crossed ectopia with fusion, the superior kidney plays the dominant rôle after fusion has occurred and is directly responsible for displacement of the inferior ectopic kidney across the midline. Since fusion of the metanephric blastema occurs at any early stage (8 mm. stage) and interferes with rotation of the two kidneys, the cephalad kidney, having ascended higher, is usually more rotated. Consequently, when the fused kidneys associated with crossed ectopia reach their permanent position, the hilus and pelvis of the superior kidney is usually directed medially, whereas the hilus and pelvis of the inferior ectopic kidney is directed anteriorly. Incomplete rotation of one or both kidneys results in several types of elongated or fused kidney.

*Incidence.* Crossed ectopia with fusion is a relatively uncommon condition but not as rare as indicated in the early reports which were based mainly on autopsy records. In 1938, Wilmer found only twelve cases in a combined series of 91,838 autopsies which is an average of about 1 per 7,500 cases. On the other hand, the incidence of simple ectopia in autopsy series is 6 to 10 times greater than crossed ectopia with fusion as indicated by the figures of Campbell who found seventy-

two in 47,477 autopsies (1:666) and of Eisendrath and Rolnick who reported 205 in 207,321 autopsies (1:1000). Thomas and Barton found only six cases of simple ectopia in 3,285 urological examinations (1:547).

Crossed ectopia with fusion is decidedly more common than crossed ectopia without fusion. In 1940, Takahashi and Iwashita collected 289 cases of crossed ectopia and found 171 cases of crossed ectopia with fusion, forty-six cases of crossed ectopia without fusion and seventy-two cases type not determined. The incidence of crossed ectopia with fusion in their experience was one in 5,308 pyelographies.

The comparative incidence of the three conditions in Culp's series of 747 pyelographic studies was unilateral ectopia three cases (1:249), crossed ectopia with fusion two cases (1:373) and crossed ectopia without fusion one case (1:747). The author recently reviewed 3,684 urologic admissions to the Sinai Hospital and found six cases of simple unilateral ectopia (1:614), two cases of crossed ectopia with fusion (1:1842), and one case of crossed ectopia without fusion (1:3684).

According to Papin and Palazzoli, the first case of crossed ectopia with fusion was reported by Panarolus in 1654. In 1938, Wilmer collected 286 cases including five personal cases. The author has collected forty-seven cases published since Wilmer's report and added four personal cases giving a grand total of 337 cases. (Table II.)

**Sex Incidence.** This anomaly apparently is observed more frequently in males than females. In the series of cases reviewed by the author, there were 163 males, 126 females, and sex not mentioned in forty-eight cases. However, the sex difference is of no great significance from a clinical or embryological standpoint.

**Side Involved.** The renal mass was situated more frequently on the right side. The side involved has no practical significance on the clinical course or embryological development. The position of the

renal mass was stated in only 284 cases and occurred on the right side in 170 cases, on the left in 106 cases and prevertebral in eight cases.

**Age Incidence.** This anomaly has been observed at all ages. The earliest case occurred in a premature fetus,<sup>7</sup> the oldest was seventy-nine years of age.<sup>40,103</sup> The distribution of cases according to age periods is recorded in Table III.

TABLE III  
AGE DISTRIBUTION

	No. of Cases
Fetus to birth.....	8
Under one year.....	16
1-10 years.....	19
11-20 years.....	30
21-30 years.....	70
31-40 years.....	47
41-50 years.....	41
51-60 years.....	17
61-70 years.....	9
71-80 years.....	4
Adults.....	29
Unknown.....	47
Total.....	337

The majority of cases recognized clinically were in patients under the age of fifty years, particularly in the third, fourth and fifth decades. Cases diagnosed at autopsy were most frequently observed in the second and third decades.

It is apparent from these figures that the duration of life is not affected by this anomaly. Many of these patients enjoy a full span of life without any significant complaints. These patients rarely die of renal disease attributable to the malformation. Many of these patients do develop hydronephrosis or infection which may be chronic or recurrent. Thompson and Allen state that these patients have a 3:1 chance of living through middle age without developing a demonstrable hydronephrosis.

**Associated Pathology.** Crossed ectopia with fusion is frequently accompanied by pathological lesions in one or both renal components and less frequently by congenital and acquired lesions elsewhere in the body. The type and severity of the coexisting renal lesions vary considerably

and tend to involve the inferior ectopic kidney more often than the superior kidney. These secondary pathologic lesions are usually due to defective drainage caused by the congenital malposition of the anomaly or to obstruction or constriction of the pelvis or ureter by the abnormal blood supply associated with this anomaly. The two most common lesions are infection and hydronephrosis.

Associated renal pathological conditions were found in 204 of the 337 cases reviewed. A variety of lesions were encountered:

TABLE IV  
ASSOCIATED PATHOLOGICAL CONDITIONS  
No. of Cases

1. Hydronephrosis	
(a) One kidney.....	41
(b) Both kidneys.....	10
(c) Pyelectasis.....	26
(d) Hydronephrotic atrophy.....	1
2. Infection	
(a) Pyelitis.....	8
(b) Pyelonephritis.....	42
(c) Pyonephrosis.....	10
(d) Renal abscess.....	1
(e) Perirenal abscess.....	1
3. Nephritis	
(a) Acute.....	9
(b) Chronic.....	7
(c) Lipoid.....	1
4. Renal calculi.....	17
5. Tuberculosis.....	8
6. Nephroptosis.....	12
7. Miscellaneous	
(a) Cystis degeneration.....	3
(b) Hypoplasia.....	2
(c) Arteriosclerosis.....	1
(d) Infarct.....	1
(e) Adenocarcinoma.....	1
(f) Traumatic injury.....	2
Total.....	204

Congenital anomalies elsewhere in the body are relatively uncommon since there is no apparent direct causal relationship between the two conditions. However, it is conceivable that both types of lesions may be caused by an inherent faulty developmental process involving more than one organ or system of organs as a result of a defective germ plasm. The following congenital malformations have been observed in isolated cases of crossed ectopia with fusion: situs inversus of all organs, persistent urachus, absence of cornus

uteri and one tube and ovary, uterovesical fistula, absence of the suprarenal gland of the opposite side, spina bifida, congenital dislocation of the hip, talipes valgus, supernumerary spleen, patent foramen ovale, hypospadias, etc. In one of the author's cases (Case IV) the renal anomaly was accompanied by three other anomalies: ectopic ureteral orifice in the uterus, a vesicovaginal fistula and atresia of the vagina.

The infrequent occurrence of congenital malformations of the genital tract in the male and female with the renal anomaly is explained by the fact that the fusion process in this renal anomaly occurs at a comparatively early stage (5 to 8 mm. embryo) whereas the development of the genital tract in the female from the Mullerian duct is initiated later, in the 11 mm. stage.

Although concomittant genital abnormalities were reported in twelve of the fifty-five cases collected by Pagel, such abnormalities are more frequently observed with congenital solitary kidney (unilateral aplasia).

The occurrence of acquired extrarenal lesions in cases of crossed ectopia with fusion is purely coincidental and the type of lesions are too diversified to merit further consideration.

*Symptomatology.* There is no symptom complex typical of crossed ectopia with fusion. The clinical picture is considerably modified by the size and location of the renal anomaly, the presence of associated pathological lesions within one or both renal components, and associated pathological lesions of a congenital or acquired nature in adjacent organs or structures. The clinical picture may be classified as follows: (1) symptomatic—renal and extrarenal; (2) asymptomatic and (3) latent.

In the majority of cases, the symptoms are of renal origin and are referable to the genitourinary tract. Symptoms of renal origin are frequently misinterpreted as they may simulate intra-abdominal, pelvic or vertebral lesions. It is generally agreed

that the uncomplicated renal anomaly *per se* rarely produced symptoms. In a small number of cases, the symptoms are of extrarenal origin and are the result of pressure of the fused renal mass on adjacent organs, i.e., gastrointestinal tract, female reproductive organs, vertebrae, nerves, blood vessels, etc., or due to reflex stimulation of these organs. The asymptomatic group is a relatively small one which includes those cases discovered accidentally during an operation for some unrelated intra-abdominal or pelvic condition, during a routine urographic study or at autopsy. It is interesting to note that Wilmer found seventeen asymptomatic clinical cases in the series of 286 cases. The latent group is the smallest and includes those cases which are asymptomatic but under special circumstances the anomalous kidney mass may cause symptoms, i.e., it may serve as a potential cause of dystocia of pregnancy.

The predominating symptoms associated with crossed ectopia with fusion are pain and a palpable mass and, less frequently, urinary disturbances. In ninety cases reviewed by Wilmer, pain occurred in seventy-one cases, palpable abdominal mass forty cases, urinary symptoms thirty-six cases, and nausea ten cases. In the fifty-one cases collected by the author, pain was present in twenty-two cases, a palpable mass eighteen cases, urinary symptoms nineteen cases, gastrointestinal symptoms six cases, and inflammation of one eye two cases.

Pain is the most common symptom. The location of the pain usually corresponds to the position of the fused renal mass and consequently is localized to the renal, iliac, lumbar, pelvic or loin area. The intensity of the pain varies with the nature of the associated pathological lesion and thus may be dull or sharp or colicky, persistent or intermittent. It may be localized or radiate into the back, loin, groin or legs.

The next most common symptom is a palpable mass. Careful abdominal palpation, rectal palpation, and bimanual pelvic

examination is essential because of the marked variations in the size, shape and position of the renal mass. The mass may be difficult to detect in stout individuals or overlooked in a cursory or perfunctory examination of a thin individual. The mass is usually irregular in shape and moves very little with respiration. The mass is of firm consistency unless a hydronephrosis or pyonephrosis is present in one of the renal segments which may produce a soft, cystic or ballotable mass. Careful palpation of the uncomplicated renal mass usually imparts a sensation of deep resistance thus distinguishing it from an intraperitoneal tumor which is more likely to be superficial and less resistant to pressure. The examining physician should bear in mind the possibility of a fusion anomaly when a symptomless tumor is palpated in the lower portion of the iliac fossa which is seldom the site of a retroperitoneal neoplasm.

Symptoms referable to the urinary tract are seldom present alone but are usually associated with an infection within the anomalous kidney. In thirty-six cases reviewed by Wilmer, hematuria was present in fourteen cases, pyuria twelve cases, polyuria seven cases and dysuria three cases. In reviewing the histories of many reported cases, one is impressed with the frequent reference to an antecedent or recurrent "pyelitis" whose etiology remains unexplained until a pyelographic study is made. This is in keeping with the fact that the fused kidney is subject to the same diseases as the normal kidney. In an occasional case when the renal mass is situated in the true pelvis, vesical symptoms may occur as a result of pressure of the mass on the bladder.

Gastrointestinal symptoms, i.e., nausea, vomiting, epigastric discomfort, constipation, diarrhea, etc., are uncommon symptoms which may predominate the clinical picture and lead to an erroneous diagnosis of an intra-abdominal lesion. These symptoms are due to pressure of the renal mass upon an adjacent portion of the

gastrointestinal tract or to reflex stimulation of these organs.

Malaise, toxemia, fever, chills, leukocytosis, etc., are observed in those cases complicated by urosepsis. Dysmenorrhea, metrorrhagia, dyspareunia, etc., are occasionally observed and are the result of pressure of a low-lying renal mass on the female reproductive organs.

Rosving's sign, i.e., pain induced by acute flexion or hypertension of the back, is rarely observed with this anomaly. It was present in one of the author's cases (Case III). It is more likely to occur when one renal segment in its entirety or in part is situated directly over the vertebral column as in the case of a sigmoid, "L" shape, disc or lump kidney.

The rôle of this fusion anomaly as a cause of dystocia has been emphasized by many authors. A review of the literature reveals that normal delivery usually ensues when the fused kidney mass is situated above the promontory of the sacrum. Several patients have experienced six or seven successive confinements without difficulty. One of the author's patients (Case II) underwent eight normal confinements. When the fusion anomaly is situated at or below the promontory of the sacrum, dystocia is more likely to occur. Geinitz reported a female of twenty-four years with a pelvic fused kidney who had two abortions. A progressive hydronephrosis resulting from repeated pregnancies in patients with a fusion anomaly may serve as an obstruction to normal labor as in the case reported by Idel. The latter's patient was a female aged thirty years who had six normal pregnancies and required a cesarean section for her seventh pregnancy because of a cystic mass filling the pelvis. The mass was erroneously diagnosed as a cystic ovary but actually was a large hydronephrosis associated with a pelvic fused kidney. Stein reported a female thirty years of age with a unilateral elongated kidney in the right iliac fossa which displaced the fetus to the left. A vaginal cesarean section was necessary

because of severe uterine hemorrhage induced by early difficult labor.

**Diagnosis.** Prior to introduction of pyelography by Voelker and Lichtenberg in 1906, the diagnosis of this condition was most often made at autopsy or in the dissecting room and occasionally at operation for some other condition. In 1909, Albarran reported the first case correctly diagnosed by retrograde pyelography. Since that time, an ever increasing number of cases have been correctly diagnosed clinically. About 75 per cent of the 337 cases reviewed by the author have been reported since 1909 and that more than 60 per cent of the cases have been reported since 1921. In the author's series, the method of diagnosis was specified in 291 cases and was made at autopsy in 120 cases, by roentgenography in 134 cases and at operation in thirty-seven cases.

The paucity of characteristic symptoms associated with this condition accounts for the fact that no cases have been diagnosed clinically without the aid of pyelography. The history is of little value in establishing the correct diagnosis for in many instances this anomaly is asymptomatic or else is accompanied by symptoms easily confused with other renal, intra-abdominal or pelvic disease.

Physical examinations may reveal a palpable mass which is rarely associated with a renal anomaly by the examiner. However, the possibility of a fusion anomaly should always be considered when a mass is palpable in the iliac fossa or pelvic region in cases of obscure abdominal or pelvic disease. The renal mass was palpated rectally by Beer and Ferber and vaginally by Bugbee.

The most important and reliable diagnostic procedure is pyelography. Cystoscopy *per se* is of little diagnostic value as the ureteral orifices are normal in size and position. Cystoscopy with unilateral retrograde pyelography may reveal an abnormality of one kidney but fails to demonstrate the true nature of the anomaly and occasionally leads to an erroneous

diagnosis of a unilateral rotated or ectopic kidney as each renal segment in this anomaly always exhibits some degree of rotation and malposition.

A plain (K.U.B.) roentgenogram may yield some valuable information. One should suspect the possibility of this anomaly when the film shows an absence of a renal shadow on one side and the presence of an unusually large or irregular shadow on the other side due to the fusion or overlapping of the two renal components. Displacement of the large bowel medially by the fused renal mass may be seen in the plain film but can be best visualized after the ingestion of an opaque media.

A plain film with opaque ureteral catheters *in situ* is a valuable diagnostic procedure. The catheter in the ureter of the crossed ectopic kidney is seen crossing the midline. Every effort should be made to pass each catheter far enough to obtain a satisfactory plain film and retrograde pyelograms which will provide invaluable information concerning the length and shape of each ureter and anatomical and pathological condition of each renal segment.

Bilateral retrograde pyelography is the most accurate method of demonstrating the real nature of fusion anomaly and any accompanying defect. This method of diagnosis was successfully employed in thirty-eight of fifty-one cases collected by the author.

In the author's experience, retrograde pyelography permits a sharper and clearer delineation of the kidneys and ureters than excretory urography. However, this limitation does not detract from the usefulness of excretory urography as a diagnostic procedure, particularly in those patients in whom cystoscopy and retrograde pyelography is impractical or unsuccessful. This method of diagnosis should be employed in all cases of obscure abdominal disease of possible renal origin before cystoscopy is contemplated or before exploratory laparotomy is under-

taken. Excretory urography also serves as a confirmatory procedure when a presumptive diagnosis is made during an exploratory abdominal operation or as a check when the diagnosis is made by retrograde pyelography. Excretory urography may fail to demonstrate the anomaly if one renal segment is diseased and its excretory function is seriously impaired. Excretory urography was employed in fifteen of the fifty-one cases collected by the author and yielded positive information in five cases, confirmatory evidence in four cases and unsatisfactory in six cases.

A knowledge of the abnormal configuration of the rotated pelves associated with this anomaly would greatly facilitate a correct interpretation of the pyelographic findings. The following pyelographic findings are more or less characteristic but by no means constant:

- (1) Superior kidney—situated at almost normal level in lumbar fossa
  - (a) Pelvis—rotated on its long axis and directed obliquely and downward toward the midline
  - (b) Calyces—directed medially
  - (c) Ureter—enters bladder on same side as kidney
- (2) Inferior (ectopic) kidney—situated at an abnormally low lumbar level, usually at or above the level of the sacral promontory
  - (a) Pelvis—rotated on its long axis and directed obliquely and downward from the lower pole of the superior kidney
  - (b) Calyces—directly anteriorly or medially, i.e., toward the side of the body the ectopic kidney would normally belong
  - (c) Ureter—crosses midline to enter bladder on the opposite side

Wilmer has employed the term "tri-angle pyelogram" to indicate the abnormal rotation of the pelves which is an almost constant feature of the simple forms of crossed ectopia with fusion. It resembles a right triangles whose base is the bladder,

the hypotheruse is represented by a line drawn through the ureter and pelvis and calyces of the ectopic kidney, and the remaining side corresponds to a line drawn through the ureter and pelvis of the superior kidney.

*Differential Diagnosis.* Inasmuch as crossed ectopia with fusion presents many variations in the size, shape and position, an accurate diagnosis may be difficult or impossible by roentgenographic methods alone and the real nature of the anomaly may be determined only by inspection at the operating table. This is particularly true when one or both renal segments present extensive changes, namely, infection, dilation of the pelvis and calyces, ureteral obstruction, etc. From an anatomical standpoint this anomaly must be distinguished from the following congenital renal anomalies:

- (1) Crossed ectopia without fusion—this anomaly is rarer than the fused type. The ectopic kidney is usually found at or below the sacral promontory and is separated by a considerable distance from other normally situated and developed kidney on the same side. (Fig. 2.)
- (2) Congenital solitary kidney (unilateral aplasia)
  - (a) Persisting kidney and ureter possess normal anatomical relations.
  - (b) Persisting kidney is a double kidney, i.e., fused supernumerary kidney, with complete or incomplete duplication of the ureter which enters the bladder on the same side as the kidney.
- (3) Other fusion anomalies
  - (a) Horseshoe kidney—fusion of lower poles of both kidneys and less frequently the upper poles. Each kidney segment is situated on its normal side.
  - (b) Prevertebral or pelvic fusion anomalies, i.e., disc, cake, or lump kidneys, with each renal

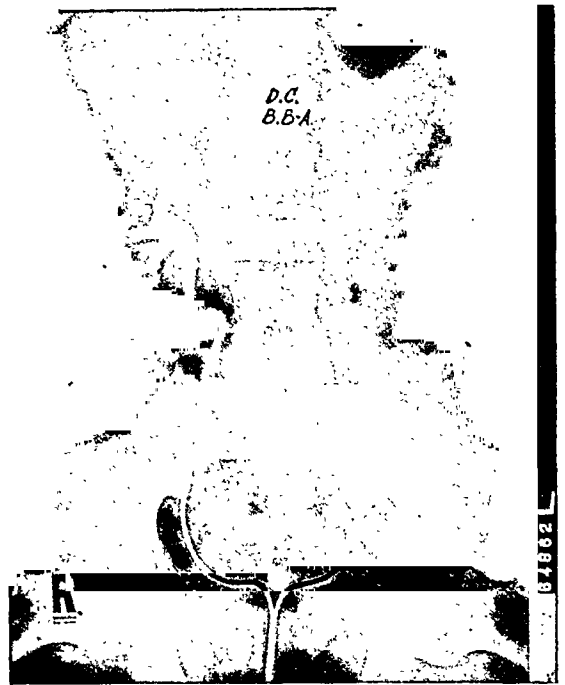


FIG. 2. Crossed ectopia without fusion in a male fifty-two years of age, suffering from hypertension. The left crossed ectopic kidney was situated over the right sacroiliac joint and was removed for chronic pyelonephritis.

segment situated on its normal side.

In the differential diagnosis of crossed ectopia with fusion, one must consider the following acquired renal lesions occurring in a normally situated kidney: ptosis, hydronephrosis, neoplasm and cyst. In most instances these renal lesions can be readily excluded by employing retrograde pyelography. Careful palpation will also enable the examiner to rule out these acquired lesions which invariably arise and are palpable at a higher level in the abdomen than the fusion anomaly.

From a clinical standpoint, crossed ectopia with fusion has been confused with a variety of renal, intra-abdominal, retroperitoneal and pelvic diseases. The following incorrect diagnosis of renal diseases have been made: ptosis<sup>3,6</sup> hydronephrosis, nephritis, pyelonephritis and pyonephrosis,<sup>2</sup> renal calculi.<sup>8</sup> The condition has been mistaken for the following intra-abdominal diseases: acute or chronic appendicitis,<sup>37,38,15,20</sup> acute cholecystitis and cholelithiasis,<sup>24</sup> tuberculosis mesenteric lymph nodes,<sup>56</sup> intraperitoneal tumors,<sup>49,55</sup> peri-



tonitis or abscess with intestinal obstruction,<sup>34</sup> tumor of the liver,<sup>72</sup> mesenteric adenitis.<sup>10</sup> The condition has also been erroneously diagnosed as a retroperitoneal tumor,<sup>81</sup> aortic aneurysm<sup>74</sup> and tuberculosis of the retroperitoneal lymph nodes.<sup>74</sup> When the fused renal mass is situated in the true pelvis, it may be mistaken for uterine fibromyomas,<sup>100</sup> ovarian cyst,<sup>100</sup> tubo-ovarian disease<sup>49</sup> etc. In the majority of these cases if a complete urologic examination including retrograde pyelography had been made, an accurate diagnosis would have been established.

*Treatment.* The treatment of crossed ectopia with fusion has always been perplexing because of the different clinical and pathological features of each individual case. In the early reports, operative treatment was often unsuccessful because of faulty or incorrect diagnosis and poor operative planning. When precise diagnostic methods are employed, the correct diagnosis is made more often, the presence of associated pathological lesions readily determined and the various symptoms properly evaluated with the result that careful operative procedures can be planned.

The chief aim of any treatment of this condition should be to effect a permanent cure of the lesion responsible for the presenting symptoms. Non-operative treatment of the infectious or obstructive lesions by catheter drainage, pelvic lavage and dilatation of the ureter have not yielded good results. With the use of the newer chemotherapeutic agents, i.e., sulfonamides, penicillin, streptomycin, etc., the necessity of utilizing such conservative measures is practically eliminated in the treatments of infections in the anomalous kidney.

The surgical treatment of this condition may be classified as conservative or radical. The ultimate choice of the type of operation should be made only after a complete urologic study and entails a careful evaluation of the following factors: (1) nature and severity of the symptoms, (2) anatomical relations of the renal anomaly, (3)

pathological changes in the renal anomaly, and (4) the general condition of the patient.

In a review of 286 cases, Foley and Wilmer found sixty operative cases and added one personal case. The author has collected twenty operative cases. A summary of the type of operations and the results are summarized in Table v.

Through the efforts of Foley, the trend of operative treatment has been directed toward conservative surgery. He has particularly stressed the value of combined symphysiotomy and nephropexy in cases presenting no significant pathological lesions. The injudicious selection of cases to be treated by this method may lead to poor results and require secondary operations. The surgeon should be cognizant of the impracticability and futility of conservative operation in the presence of severe pathologic lesions of an obstructive or infectious character.

Radical operation consists of removal of one renal component which has been designated as resection, heminephrectomy or partial nephrectomy. This type of surgery is the operation of choice in the majority of cases for it insures a permanent cure by complete removal of the diseased component of the anomaly. In the hands of the well trained genitourinary surgeon, the operation can be performed with great facility and minimum shock. The question of simultaneous partial or complete ureterectomy must be governed by the same factors that determine its employment in the case of the removal of a normally situated kidney for any renal disease.

A conservative or radical operation on this type of anomaly demands an orderly plan of operation to obtain a good result. It must be borne in mind that in an occasional case, certain anatomical and pathological complications, such as abnormally fixed kidney, bizarre fusion, abnormal vascular supply, etc., may exist which may interfere with the execution of one or more steps in the following operative plan which is particularly applicable to

TABLE V  
OPERATIVE CASES

Type of operation	Foley and Wilmer Cases	Result		Abeshouse Cases	Result	
		Recovered	Died		Recovered	Died
A. Conservative						
1. Nephropexy of total mass.....	7	6	1	1	1	
2. Nephropexy of ectopic kidney with symphysiotomy.....	5	5				
3. Pyelolithotomy						
(a) Unilateral.....	8	8	..	2	2	
(b) Bilateral.....	..	..	..	1	1	
4. Ureterolithotomy.....	2	2	..	1	1	
5. Decapsulation.....	1	1				
6. Nephro-ureterolysis.....	1	1				
7. Pyelocystostomy.....	1	1				
8. Division of anomalous vessel.....	1	1	..	1	1	
9. Pyeloplasty (Albarran orthopedic resection)	..	..	..	1	1	
10. Ureteropyelostomy.....	..	..	..	1	1	
11. Pyelostomy with peritoneal marsupialization.....	..	..	..	1	..	1
B. Radical operation						
1. Heminephrectomy						
(Removal of one kidney segment).....	22	20	2	2	2	
(a) One case followed by ureterocutaneous implantation.....	..	..	..	1	1	
(b) One case preceded by pyelostomy terminated fatally.....	..	..	..	1	..	1
2. Total nephrectomy (71, 53, 109, 91, 52) (removal of both kidneys).....	5	5				
C. No major operations on kidney						
1. Exploratory laparotomy.....	8	6	2	2	2	
2. Exploratory laparotomy with appendectomy	..	..	..	2	2	
3. Exploratory laparotomy with biopsy of kidney.....	..	..	..	1	1	
4. Lumbar exploratory.....	..	..	..	1	1	
5. Hernioplasty.....	..	..	..	1	1	
Total.....	61	51	10	20	18	2

TABLE V  
CONCLUSIONS

Total operations.....	81
Total deaths.....	12
Total operative mortality.....	14.8 per cent
Operative mortality (exclusive of 5 fatal cases of total nephrectomy).....	6.1 per cent

removal of one renal segment or to symphysiotomy with or without nephropexy of the lower ectopic kidney:

(1) *Proper Surgical Approach.* When the renal mass is situated at or above the sacral promontory, an extraperitoneal approach through a lateral abdominal incision, i.e., pararectus or Gibson incision, is preferable. When the mass is situated

within the pelvis or lies over the lower portion of vertebral column, an intra- or extraperitoneal approach through a suprapubic midline incision may be necessary.

(2) *Identification of Each Ureter.* This step avoids unnecessary damage and simplifies exposure and identification of each pelvis. Identification of ureters may be

facilitated by passing a ureteral catheter up each ureter prior to operation.

(3) *Identification of Blood Supply of Each Renal Component.* Temporary compression of the nutrient vessels enables the surgeon to determine the amount of renal tissue supplied by these vessels. Each vessel should be doubly ligated prior to severing it for any reason.

(4) *Division of the Renal Segments (Symphysiotomy).* The incision should be made through healthy tissue, avoiding if possible, opening into the pelvis and calyces of either renal segment. The author prefers wedge-shape incisions with the point of the wedge directed toward the superior kidney. This type of incision lends itself more readily to close approximation of the cut surfaces and accurate hemostasis. In some cases of irregular fusion, this type of incision is not feasible. In the simpler forms of fusion, notching or ridging may delineate the point of fusion or isthmus between the superior and inferior renal segments.

(5) *Accurate Hemostasis.* This may be obtained by employing a through-and-through Tuffier suture or interrupted mattress sutures. Each suture should be underpinned with a piece of fat after the method of Beer and Hagenbach. A piece of fat or fibrin foam may be placed in the wedge prior to the insertion of these sutures to control capillary oozing.

(6) *Accurate Closure and Drainage of the Operative Wound.* Proper closure and adequate drainage of the wound insures prompt healing.

#### CASE REPORTS

CASE I. (A658)\* I. A., a thirty-three year old, white male, was referred to me by Dr. Ullman and Dr. Zinberg. He was admitted to Sinai Hospital on July 22, 1934, at 11 P.M. with a diagnosis of chronic appendicitis. Physical examination showed nothing abnormal. The leukocyte count was normal. The urine contained several red blood cells

\* Previously reported in *Am. J. Digestive Dis. & Nutrition*, 2: 477, 1935.

and pus cells which presented the first indication of the presence of a urinary tract disease.

For five months prior to admission, he complained of a dull pain in the lower abdomen in the midline which lasted a few minutes and recurred at irregular intervals. For the past month, the pain had shifted to the lower right quadrant and was cramp like in character. The pain was not related to meals, exercise or defecation and was not accompanied by chills or fever. There was nausea but no vomiting. Marked constipation was present. There were no urinary complaints. The last attack of pain was three days prior to admission.

Cystoscopy was performed on July 23, 1934. The bladder walls were normal. Both ureteral orifices appeared to be normal in size, shape and position. Clear urine escaped from each orifice. A no. 6 catheter was passed up each ureter. A plain film (Fig. 3) with the ureteral catheters *in situ* showed (1) the right ureteral catheter to be arrested at the sacral promontory and the left catheter crossing the midline to a point over the fourth lumbar vertebra. (2) an irregular oval shadow (2 cm. by 1.5 cm.) was situated opposite the junction of the first and second lumbar vertebra on the right side, and (3) no renal shadow on the left side.

A bilateral retrograde pyelogram (Fig. 4) was made and revealed a crossed ectopic kidney with fusion (unilateral elongated kidney) with the shadow (calculus) in the middle calyx of the inferior ectopic kidney. The pelvis of the superior kidney was directed medially and the pelvis of the ectopic kidney pointed anteriorly.

Pyelolithotomy was performed on April 23, 1934. The operation was performed through a high right pararectus extraperitoneal approach (Gibson incision). He made an uneventful recovery and was discharged from the hospital on May 15, 1934, twenty-one days after operation.

A follow-up study including intravenous urography was performed on January 4, 1939, and on March 7, 1944, and revealed no pathological changes within the renal anomaly.

CASE II. (A-4067), R. L., a seventy-seven year old widow, was referred to the office by Dr. Grossman on August 21, 1945, complaining of pain in right lumbar area and urinary symptoms. The patient had always enjoyed good health and had undergone eight confinements with no difficulty. For six weeks prior



FIG. 3. Case 1. Roentgenogram with ureteral catheters *in situ*. The shadow opposite the junction of the first and second lumbar vertebrae is a stone in the left crossed ectopic (inferior) kidney. Left ureteral catheter crossed the midline to the right.

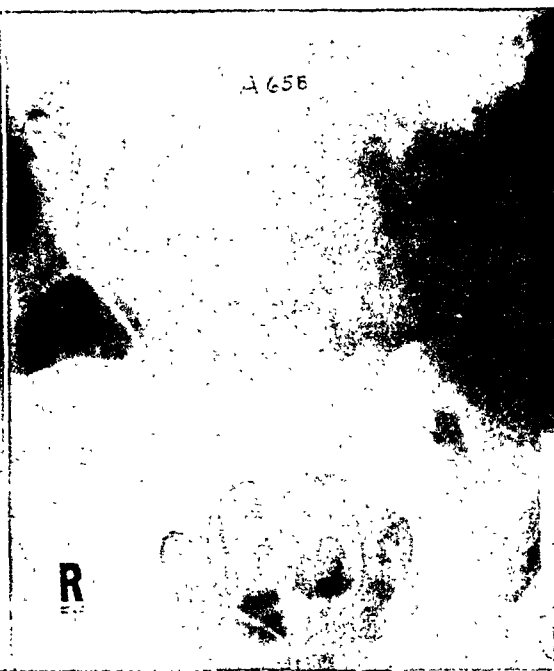


FIG. 4. Case 1. Bilateral pyelogram showing a crossed ectopia with fusion situated on the right side. The calculus is situated in the upper calyx of the inferior crossed ectopic kidney and was removed by pyelolithotomy.

to examination she had complained of dull persistent pain in the right lumbar area which was accompanied by slight fever but no radiation of pain. She also had urgency, hesitancy, diurnal and nocturnal frequency and dysuria. Treatment with sulfadiazine and penicillin was instituted by her family physician with good results but a recurrence of symptoms was noted upon cessation of chemotherapy. No cardiorespiratory or gastrointestinal symptoms.

Physical examination was negative except for a palpable mass in the right side of the abdomen which was slightly irregular, tender and movable with respiration. A catheterized specimen showed a faint trace of albumin and 3 to 4 red blood cells per high power field. A stained smear of urinary sediment revealed staphylococci.

A plain x-ray of the abdomen revealed an enlarged but irregular outline of the right kidney situated at a lower level than normal. There was no renal shadow visible on the left side. Intravenous urography was unsatisfactory as the amount of dye in the right kidney in the flat and upright position was insufficient to outline the kidney pelvis. There was no dye in the left renal area.

Cystoscopy and retrograde pyelography was

performed on August 29, 1945. There was a contraction of the vesical orifice with granular and cystic changes in the mucous membrane of the vesical orifice. There was a moderate congestion throughout the entire bladder. A small diverticulum, admitting a catheter for a distance of 2 cm. was found about 1 cm. above and lateral to the right ureteral orifice. Both ureteral orifices were normal in size, shape and position. A no. 6 catheter was passed up each ureter for 16 cm. with ease. Clear urine obtained from each kidney which revealed an occasional pus cell with staphylococci. The right pelvic capacity was 6 cc. and the left 8 cc.

A plain plate (Fig. 5) with the ureteral catheters *in situ* showed the left catheter crossing the midline just above the promontory of the sacrum. A bilateral pyelogram (Fig. 6) following the injection of 20 per cent Skiodan showed a crossed ectopia with fusion. The lower pole of the superior kidney was fused to the upper pole of the inferior (ectopic) kidney, i.e., unilateral elongated kidney. There was a kink of the right ureter at the ureteropelvic junction.

Diagnosis: (1) Crossed ectopia with fusion (unilateral elongated type); (2) acute cystitis;



FIG. 5. Case 11. Roentgenogram with ureteral catheters *in situ* reveals the left ureteral catheter crossing the midline to the right.



FIG. 6. Case 11. Bilateral pyelogram showing a crossed ectopia with fusion on the right side. A mild degree of pyelectasis is present in each kidney.

(3) acute pyelonephritis, bilateral, (staphylococci); (4) diverticulum of bladder and (5) contracture of vesical orifice.

The urinary infection cleared up with penicillin therapy supplemented by dilatations of the vesical neck.

CASE III. E. H., a white female, forty-five years of age and married, was first seen by my colleague, Dr. J. Goodman on January 27, 1942. Her chief complaint was vaginal bleeding. She also complained of pain in the left lumbar region and left lower quadrant. Physical examination was essentially negative except for tenderness over the left lower quadrant. No masses were palpable. Pelvic examination disclosed a moderate cystocele and the uterus fixed in an anterior position as a result of a Wertheim Watkins operation performed six years previously. Cystoscopy was performed and revealed a normal right ureteral orifice, but the left ureteral orifice was not located due to marked congestion and edema in this area. A panhysterectomy was performed and patient made an uneventful recovery.

The patient returned on January 28, 1946, complaining of dull pain in the left lower quadrant which has recurred with increasing frequency and severity in the past two years. The pain was aggravated by bending. She also complained of urgency and frequency of

urination. Examination was negative except for tenderness in the left lower quadrant. The urine was negative except for an occasional pus cell.

Cystoscopy revealed both ureteral orifices to be normal in size, shape and position. A bilateral retrograde pyelogram (Fig. 7) revealed a crossed ectopia with fusion. The two kidneys were located on the left side with the crossed ectopic kidney situated inferiorly. The pelvis and calyces of both kidneys were directed medially.

CASE IV.\* (U-1290 7-1), E. R., thirteen months old, white female was admitted to the pediatric service of Sinai Hospital on December 26, 1936. The chief complaint was cough and fever of two days' duration. The family history was negative. The patient was a full term baby delivered instrumentally and weighed 11 pounds 14 ounces at birth. It was noticed that at birth she had a "deformed spine" but suffered from no hemorrhage or convulsions. She had developed normally except for bronchopneumonia in March and October, 1936. The mother noted that the child was constantly wet and required continuous change of diapers.

For two days prior to admission, she was troubled with a cough and fever which became

\* Previously reported in *Urol. & Cutan. Review*, 47: 447, 1943.

progressively worse. She refused food but took liquids. On admission, her temperature was 105°F. (rectal), pulse 180, respirations 80. Examination disclosed an acute tonsillitis and pharyngitis and signs of pneumonic consolidation over the left lung. She had a kyphosis in the thoracolumbar area with a scoliosis in the lumbar area. Roentgen examinations were made of the vertebral anomalies and also revealed an absence of the lower ribs. The leukocyte count was 22,500 with 79 per cent polymorphonuclear leukocytes. The urine was negative except for an occasional red blood and pus cell. The Wassermann reaction was negative.

The patient was placed on sulfapyridine therapy (7½ gr. every six hours) and the temperature dropped to normal in twenty-four hours. On the second day while being fed, the patient suddenly ceased breathing.

A partial autopsy was performed about two hours after death. The positive findings exclusive of the genitourinary tract were (1) bilateral bronchopneumonia, (2) pulmonary atelectasis, lower left lobe, (3) congenital absence of left adrenal gland, (4) congenital kyphoscoliosis of thoracolumbar vertebrae, (5) congenital bilateral absence of the twelfth rib and (6) congestion of spleen and liver.

The chief findings of interest were in the genitourinary tract. (Fig. 8.) In order to facilitate a careful study, the kidneys, ureters, bladder, uterus and vagina were removed intact. A detail description of the findings are presented.

○ A large kidney mass was situated on the right side at a lower level than normal and part of the renal mass was situated over the vertebrae. The lower portion of the mass was the right kidney which measured 5.5 by 3 by 2 cm. The left kidney, which was situated at the upper pole of the mass measured 2 by 1 by 1 cm. The kidneys were covered by a thin layer of retroperitoneal fat and peritoneum.

On cross section, the cortex and medulla of each kidney appeared to be of normal architecture. The right cortex measured 5 mm. and the left cortex 2 mm. The right renal pelvis was of the intrarenal type and consisted of two major calyces. The left pelvis was of a similar type but rudimentary in character. The right adrenal gland was found in its normal position but separated from the right kidney. It weighed 16 Gm. and appeared normal on gross examina-

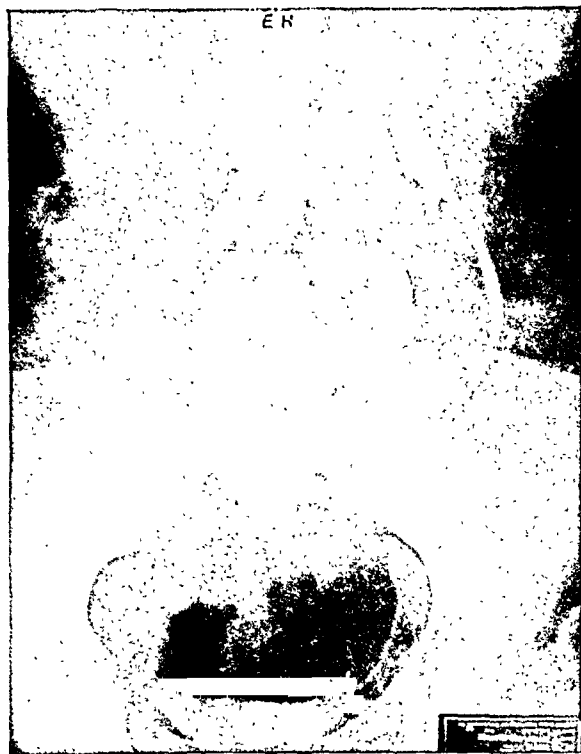


FIG. 7. Case 111. Bilateral pycelogram showing a crossed ectopia with fusion on the left side.

tion and cross section. The left adrenal was absent.

Emerging from the hilus of the right kidney was a normal sized ureter which presented several kinks and twists in its midportion as it coursed downward into the pelvis. The ureter from the upper left kidney was decidedly thinner and almost filamentous in character. The ureter from the lower right kidney passed down on the right side of the body. The ureter from the upper left crossed ectopic kidney began slightly to the right of the vertebrae and passed down on the left side of the body.

A small incision was made in the lower portion of the right ureter. A small probe was passed and entered a large mass in the bladder area which was dumbbell shaped with a central transverse constriction and measured 6 by 3 cm. This mass was opened in the lower portion and revealed about 15 cc. of urine in the lower end within a pouch-like sac which resembled the urinary bladder. The incision was extended upward and in the upper portion of the sac a structure resembling the cervix uteri was found above the bladder and this was surrounded by a pouch which resembled the vagina and contained about 30 cc. of urine. The cervix was incised and found to open into an infantile uterus which formed the upper portion of the dumbbell mass described above. The uterus

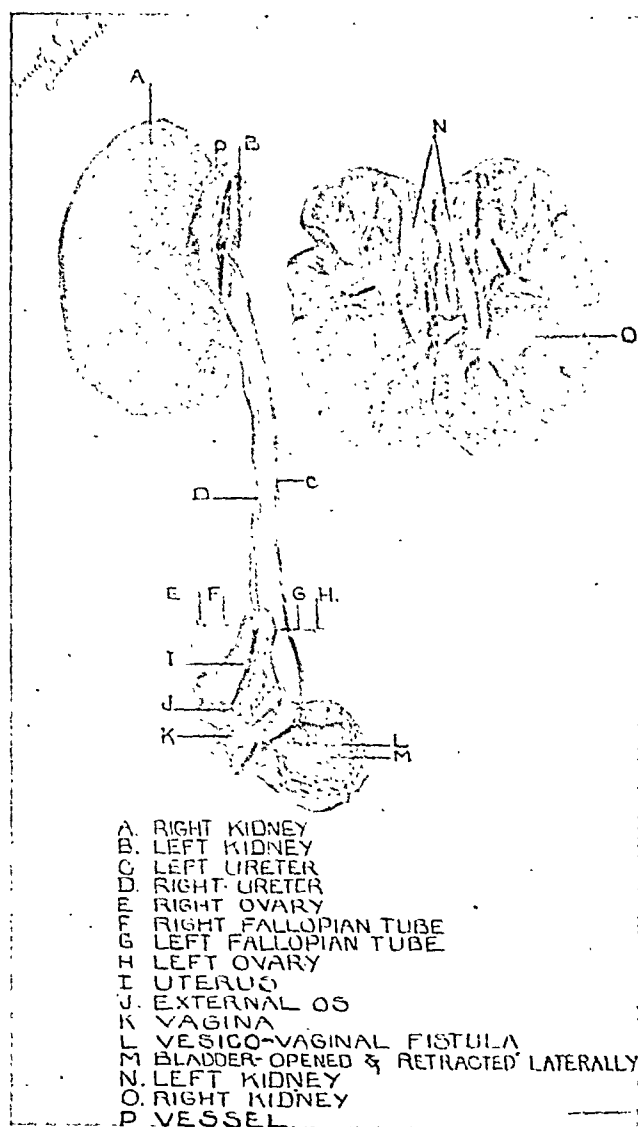


FIG. 8. Case iv. Drawing of pathological specimen showing (1) ectopic ureter opening into uterus, (2) crossed ectopia with fusion and (3) congenital vesicovaginal fusion.

was very small but appeared complete in all respects, i.e., a small cervix, tiny endometrial cavity, two small Fallopian tubes (1.5 cm. in length) with a tiny pea-sized ovary (2 mm. in diameter) at each end. The probe which was passed down the right ureter emerged into the upper fundic portion of the uterine cavity.

A small incision was made into the lower portion of the thin left ureter and a fine silkworm probe was passed down for a short distance but met an impermeable obstruction about 0.5 cm. from the bladder. It was apparent that the left ureter entered the bladder but was occluded in its lower portion. Careful examination of the bladder revealed a ureteral orifice on the

left side near the fundus of the bladder but the silkworm probe encountered an obstruction about 0.5 cm. up in the left ureter. There was no ureteral orifice in the right side of the bladder.

The bladder and vagina appeared to communicate with each other and formed a large cloacal cavity. The lower end of the vaginal portion of the cloaca was sealed off from the lower external portion of the vagina. A silver probe was passed through the urethral orifice of the bladder and appeared unobstructed at the external urethral orifice. Close inspection of the external genitalia revealed no unusual changes. The septum between the urethral

and vaginal orifices was intact. A probe was passed into the vagina for a distance of 2 cm. and the vaginal vault was found to be closed off from above.

The microscopic findings were consistent with the above descriptions and do not warrant further elaboration. The final diagnosis in regard to the genitourinary tract was: (1) Crossed ectopia with fusion (left ectopic kidney in superior position); (2) ectopic right uretral orifice in uterus; (3) congenital stricture of left ureter; (4) congenital displacement of the bladder and vagina; (5) congenital atresia of the vagina; (6) congenital vesicovaginal fistula; (7) cloacal anomaly, and (8) congenital absence of the left adrenal gland.

### CONCLUSIONS

1. The author has collected forty-seven new cases of crossed ectopia with fusion and has added four personal cases which brings the total of reported cases to 337. On the other hand, this anomaly is encountered about once in every 7,500 autopsies.

2. These figures would indicate that this condition is one of the rarer forms of congenital renal anomalies. The author is of the opinion that the above figures do not reveal the true incidence of the condition as undoubtedly many more cases have been encountered but have not been reported for various reasons.

3. The generic term—crossed ectopia with fusion—is more desirable than unilateral fused kidney or unilateral elongated kidney. The latter terms are ambiguous and are easily confused with other unilateral congenital anomalies of the kidney.

4. There are six anatomical varieties of this anomaly which are presented in the order of relative frequency: viz., (1) elongated (with ectopic kidney in inferior position), (2) sigmoid (S), (3) "L" (transitional form), (4) disc (fusion of medial borders), (5) lump (irregular fusion) and (6) elongated (with ectopic kidney in superior position).

5. The age and sex incidence of this anomaly apparently has little significance from an embryological or clinical stand-

point. In the 337 cases reviewed, sex incidence ratio was 4 males to 3 females. The majority of the cases occurred in individuals below the age of fifty years, particularly in the third, fourth and fifth decades of life.

6. There is no symptom-complex characteristics of this anomaly. The outstanding symptoms are pain and a palpable mass which are frequently accompanied by various urinary symptoms or abnormal urinary findings.

7. The diagnosis was made by autopsy in 120 cases, particularly in the early reports and in necropsies of children dying of various diseases. An accurate clinical diagnosis was made by urographic methods in 134 cases and at operation in thirty-seven cases.

8. The most important diagnostic method is retrograde pyelography. Failure to make an accurate preoperative diagnosis may lead to dire results.

9. This anomaly is accompanied by various renal diseases, particularly infection and dilatation of the pelvis. The crossed ectopic kidney is more susceptible to these pathological lesions than the non-crossed kidney.

10. The surgical treatment may be conservative or radical and is governed by the nature of the pathological lesion, the extent of fusion deformity and the condition of the patient.

11. Conservative or palliative surgery can be undertaken in this anomaly with as little risk as in the normally formed kidney. Symphysiotomy combined with nephropexy may be employed with good results in cases presenting no significant pathological lesions but accompanied by pain of renal origin.

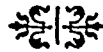
12. Radical operation consists of removal of one renal component of the fusion anomaly, i.e., heminephrectomy. It is a safe surgical procedure which can be performed with great facility and minimum shock by the well trained genitourinary surgeon in the absence of unusual anatomical or pathological complications.



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# IMPROVED GRAFTING TECHNIC FOR BURNS OF THE EXTREMITY

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A SATISFACTORY technic for skin grafting large granulating burns has been a problem in Army general hospitals. A presentation is being made of the following procedure because it has certain advantages, especially in large single plaque burns of the extremities. The end result has little or no scar tissue. The graft is more pliable and durable, eliminating the possibility of future skin grafting on the same individual.

After observing a large number of severe burns, particularly of the extremities, we have noticed that this method yields minimal loss of graft and requires fewer postoperative dressings. The healing of the grafted area is more rapid than where the grafts have been placed either over the granulations or upon a pared surface. The above factors are very important in rapid rehabilitation of burned casualties of the Army. This technic is exacting and somewhat time consuming so that a well trained team is advantageous.

## OUTLINE OF GRAFTING TECHNIC

1. Grafts taken in a wide sterile field with no contamination from burn areas.
2. Burn extremity prepared for surgery with saline compress. A compression Esmarch bandage is applied from toe to tourniquet level.
3. Tourniquet applied.
4. Blunt avulsion of granulation tissue down to fat.
5. Suture of perforated grafts edge to edge. Grafts are perforated in direction of Lines of Langer of burned extremity.

6. Application of circular gauze dressings moistened with physiological saline. Outer dressing of woven elastic type for splinting.

## PREPARATION OF PATIENT

Early burn cases should be given adequate supportive therapy. During debridement, grafting and postoperatively, patient should be on vigorous and active supportive therapy.

Pressure dressings over fine mesh ointment gauze alternated with wet saline dressings over fine mesh gauze and at times saline baths are the ideal preoperative necessities to burn care. After four to five days rest from débridement, ointment dressings, saline baths and saline compresses may be used as indicated by the condition of the patient and the amount of infection present. Sulfatherapy as well as penicillin naturally is used when indicated.

Burns should be prepared for grafting ten to twenty days after the initial accident. Skin coverage at the earliest possible time following the burn saves lives by preventing loss of body fluid and saves contracture and functional loss by the rapid subsidence of infection.

If an extremity is to be grafted, the area is prepared ten days before surgery by wet physiological saline compresses every four hours day and night. All hair in the immediate vicinity of the burn is removed as well as any macerated epithelium. A dressing is done just prior to the surgical procedure so that maximal drainage is removed on entry to the surgical amphitheater. The burn granulations are prepared in surgery by cleansing the

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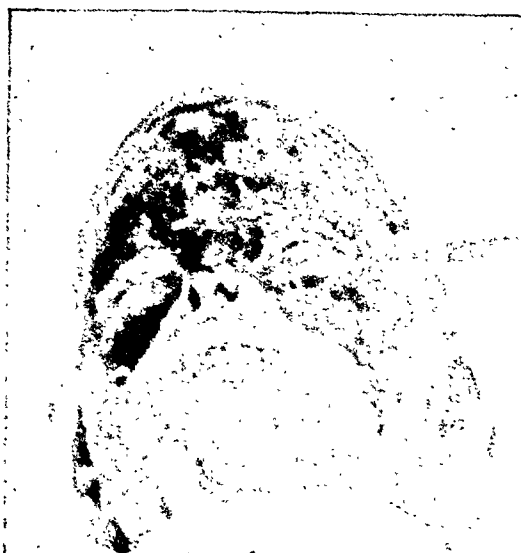


FIG. 1. Air crash burn of face, six weeks old.

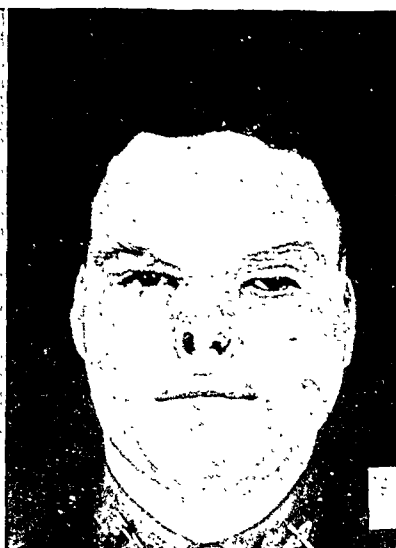


FIG. 2. Thick split graft to forehead. Perforations in lines of Langer; granulations avulsed; grafts applied ten days after receipt of patient; definite surgery incomplete.

granulations with ether and, following this, the surrounding skin is prepared in the usual manner for any surgical procedure. Granulations should be cherry red and without observable drainage. Two dermatomes are used to take the grafts which are usually .020 to .030 of an inch thick. When there is an area which may be covered in one procedure, having two operators take grafts alternately from the back, abdomen or chest, greatly speeds up the procedure and decreases anesthetic time.

The donor sites are then covered. A sterile Scultetus binder may be placed beneath the patient within sterile towels prior to surgical preparation of the donor site and at the end of the procedure may be unrolled and thus used to cover the donor site with a rapid, uniform and stable sterile dressing. After application of xeroform ointment gauze dressing on the donor site, one may turn to the contaminated burn.

The extremity is then elevated and a pneumatic tourniquet is applied following a compression bandage of Esmarch type or bias muslin which has been wrapped from the tip of the extremity up to just below a point in the region of the tourniquet so as to produce an avascular extremity. The infected granulations are then avulsed with the handle of a Bard-Parker knife. Ten to fourteen days gives adequate

time for the granulations to form a cleavage plane through which the scalpel handle may slip leaving a bed of edematous fat traversed by superficial veins. The central portion will slip off readily except for an occasional spot where skin has remained intact. This may be left as an island to perforate the graft. If the blade handle is then used to undermine laterally the edges of the burn, it will be found that a cleavage plane is present which carries back to normal vascular skin borders. Following this slight undermining, the purple edematous granular edge may be removed leaving a perpendicular skin edge. Thus one has a viable recipient bed for the graft, free of tissue with impaired vascularity. As all scar producing elements have been removed, it is the desired recipient site for any graft.

While the graft recipient site is being prepared, the nurses are perforating the grafts and a junior surgeon is suturing grafts together at one edge as this will speed the procedure. The perforations are placed in line with the Lines of Langer of the recipient extremity. This makes a more normal end result with less contracture. The graft is then tailored into position and



FIG. 3. Third degree burn of back, three weeks after injury.

FIG. 4. Thick split graft replacement; grafts applied one week after débridement.

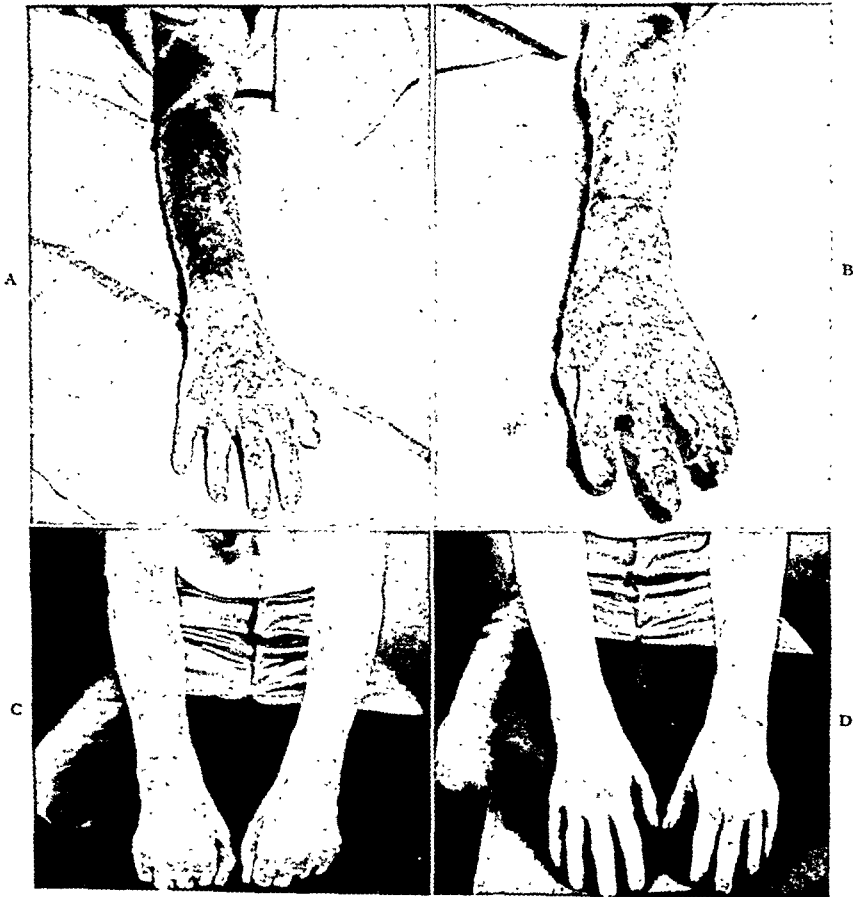


FIG. 5. A and B, air crash burn of hands and forearms, ninety days following injury. C and D, thick split grafts, applied tenth and twentieth days following receipt of case, by described technic.

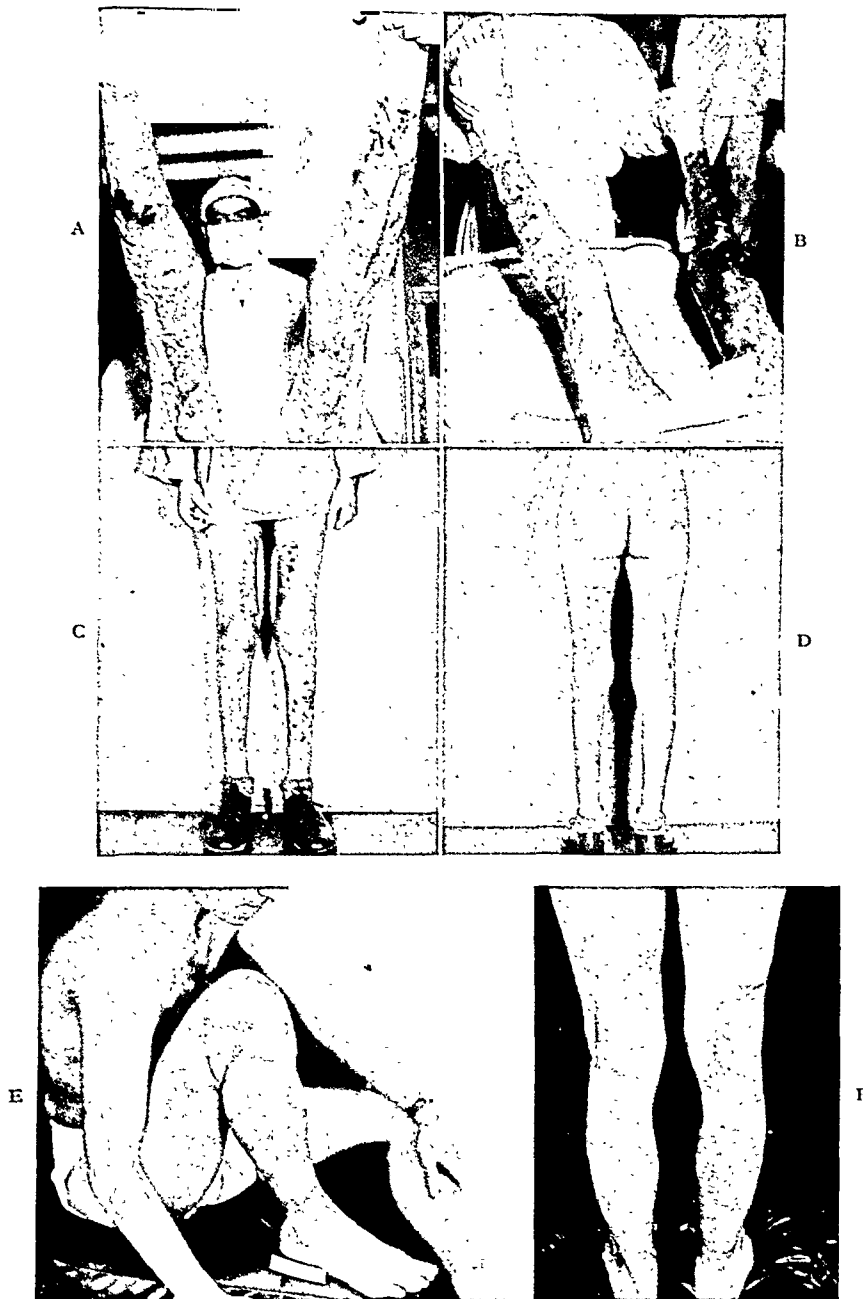


FIG. 6. A and B, air crash burns of legs, ninety days following injury. C and D, thick split graft, result twenty-one days following application of grafts; E and F, end result of grafting technic. Only one grafting procedure was necessary for entire right leg.

sutured edge to edge with a running locked suture of fine silk. The leg is still under tourniquet and no vessels are tied. With *care* hemostasis may be obtained by the final dressing. The graft is then sprinkled lightly with sulfathiazole powder. It has been observed that the powder absorbs early secretions and allows dressings to be removed without disturbing grafts. We have found that it is absolutely necessary to have a pressure stent of several layers of wet gauze bandage in depressed areas such

as about the malleolus and in the popliteal fossa. In raised areas such as over the malleolus and over the crest of the tibia, the opposite is true and lateral pressure dressings should be applied so as to prevent excessive direct pressure upon these areas which will cause necrosis of the graft. A pressure dressing of roller gauze moistened with sterile physiological saline is applied evenly and smoothly around the extremity. This usually consists of a five yard roll of gauze which has four to five layers. It is



FIG. 7. A, compression bandage prior to tourniquet; B, avulsion of granulation leaves ideal recipient site; C, perforated thick split grafts applied under tourniquet; D, proper wet saline pressure dressing with hand in "position of function." Tourniquet is removed after application of dressing.



FIG. 8. A, graft being applied to leg after avulsion technic under tourniquet.



FIG. 8. B, example of similar burns treated with pinch grafts. Note deformed area of donor sites.

wrapped circularly with enough pressure to prevent any hematoma forming beneath the graft, without embarrassment of circulation of the extremity itself. The dressing must start at the toe or finger tip and gradually decrease its pressure proximally. The foot, knee and groin and points where decubitus ulcers might occur are well protected with abdominal pads. Following this a dry gauze roll, as previously described, is used to protect the wet dressing and further immobilize the extremity. Woven elastic type bandages are then used under careful tension for splinting and as an overall dressing. The toes or fingers are left exposed so that they may be watched for any embarrassment of circulation. The pneumatic tourniquet is then removed. The extremities are elevated

and remain so through the full healing time.

The first dressing is done on the third day and if no drainage is present may be changed at once from saline to xeroform. Sutures are removed from the fourth to sixth day as indicated.

#### SUMMARY

A satisfactory technic in a large hospital installation for treating large burned areas has been presented. Its advantages are: (1) An ideal recipient site. (2) The absence of infected, scar-forming granulations beneath the grafts. (3) Minimal postoperative dressings. (4) Shorter healing period. (5) A resulting softer, more pliable and durable graft.





# MERCURY—ITS RÔLE IN INTESTINAL DECOMPRESSION TUBES

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DETROIT, MICHIGAN

THE rôle of mercury in the balloon of intestinal decompression tubes appears to be misunderstood. Most surgeons are under the erroneous impression that it is the weight of the mercury that carries the intestinal decompression tube down the gastrointestinal tract. The effect of gravity upon the weighted head of the tube is thought to constitute the propulsive mechanism.

The use of mercury in intestinal obstruction is not new. One hundred fifty years ago mercury was used by mouth in its free form in the treatment of bowel obstruction. In the Index of the Surgeon General from the years 1780<sup>1,2,3</sup> to 1850<sup>4,5,6</sup> no less than fifty articles can be found describing the action and use of metallic mercury by mouth in the treatment of bowel obstruction. Although this method of treatment fell into disrepute for obvious reasons, certain fundamental points were learned by these surgeons. First, it was not the weight of the mercury that was of value, but it was the fluidity, the lability, the very "quick-silver" qualities of the mercury and its marked power of cohesion that were the desirable physical properties of the mercury. Further, it was found that liquid mercury was completely innocuous in the gastrointestinal tract. These two points constitute the most desirable physical properties of mercury.

The first use of mercury in a gastroduodenal tube appeared in 1928 with the publication by Wilkins<sup>7</sup> of a mercury weighted gastroduodenal tube. This tube was  $\frac{3}{16}$  inch in diameter and the mercury was packed solidly into the head end of the tube. (Fig. 1.) An examination of this figure, readily discloses the obvious fact that the only physical property of mercury

utilized here was the weight. Because the mercury was closely confined in so small a space, there was no opportunity for the lability and cohesive power of mercury to be utilized. The very title of the paper indicates quite clearly that the weight of the mercury was the prime object.

The next reference to the use of mercury in intestinal decompression tubes was the paper by Harris<sup>8</sup> and the work of Sivertsen,<sup>9</sup> in which the mercury was placed into the balloon of a Miller-Abbott tube in an effort to weight it and to get the effect of gravity upon the "weighted" head of the tube. Here again, we note that it is weight that was the chief property desired. Harris<sup>10</sup> in his single lumen tube used the same position of the balloon along the shaft of the distal end of the tube (Fig. 2), but placed 4 cc. of mercury in the balloon. It should be quite evident from an examination of Figure 2 that as long as the shaft of the tube passes through the balloon containing the mercury there can be no "free-flow" of mercury. The shaft of the tube must of necessity limit the lability of the mercury with the result that again the only physical property of the mercury utilized would be its weight\* and the effect of gravity upon its weighted head.

If it were merely weight that was desired in the head end of an intestinal decompression tube, there are other elements that are heavier than mercury and hence more desirable from that point of view. An examination of the table of elements and their atomic weights,<sup>11</sup> disclosed the fact that there are eight elements whose atomic

\* The Pilling Company in their advertisements in the *Annals of Surgery* advertise the "Harris Mercury Weighted Tube." Here again, we find weight as the essential point.

Nov. 19, 1929.

J. A. WILKINS

1,736,182

STOMACH TUBE

Original Filed Dec. 12, 1927.

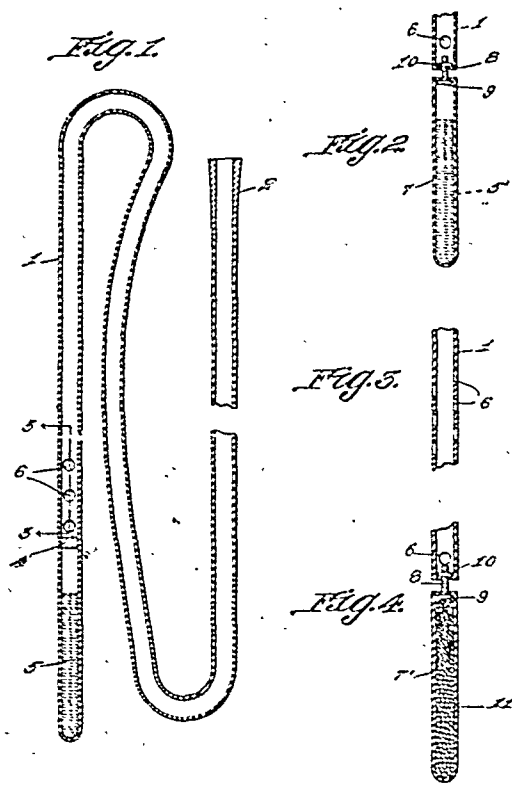


FIG. 1. In the Wilkins tube the mercury is tightly packed into the distal end of a  $\frac{3}{16}$  inch tube; weight only is utilized here. No mobility of the mercury possible.

weights exceed that of mercury with an atomic weight of 200.61. Some of these elements such as radium (atomic wt. 225.95), radon (atomic wt. 222), and thorium (atomic wt. 232.15) cannot be used because of their physical property of radioactivity. This property makes their use to weight and the head of an intestinal decompression tube impossible. Thallium (atomic wt. 204.39) cannot be used because of its toxicity in the event that the balloon would break freeing the thallium into the gastrointestinal tract. Bismuth (atomic wt. 209) is much too brittle as a metal and not readily available. It has no fluidity or cohesive power that would make its use in the head of a tube desirable. The only remaining element heavier than mercury is lead (atomic wt. 207.20). If it is weight alone that is desired, why not use lead which is heavier than mercury? In addition

to being heavy, it is relatively non-toxic in the gastrointestinal tract because it would be excreted before much absorption could occur. It should be quite apparent that although lead is heavier than mercury, its other physical properties of being a solid mass and inert would not fit it well for use in an intestinal decompression tube which is expected to pass through "sinuous passageways with sphincters" as is found in the gastrointestinal tract. Mercury, on the other hand, because of its fluidity and cohesive power is eminently suitable for use in the balloon of an intestinal decompression tube because it literally flows downward through narrowed portions of the bowel and passes sphincters easily.

Since mercury is to be used in the head end of the intestinal decompression tube, such tubes must be constructed to utilize the physical properties of mercury to the

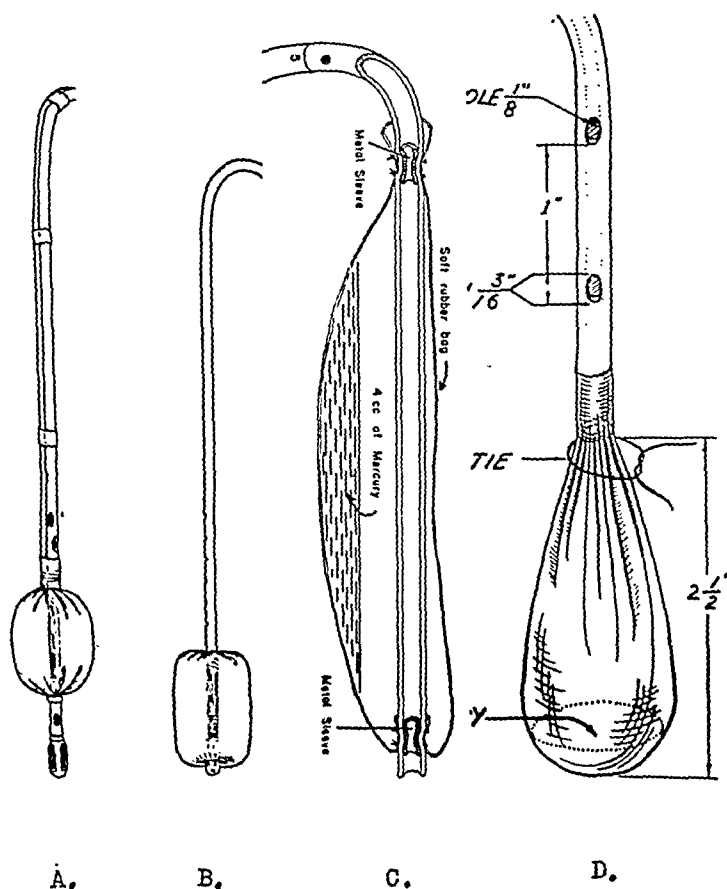


FIG. 2. The tube "heads" illustrated here are: A, Johnston; B, Miller-Abbott; C, Harris; D, Cantor. Note the close similarity between the head of A, B and C. In all three the shaft of the tube passes through the balloon and the end of the tube is open. Note that in the Cantor tube a loose balloon is applied at the tip.

utmost and not merely its weight. Metallic mercury is liquid even at the lowest temperatures. It is a coherent, mobile liquid, which does not wet glass or objects placed in it. It remains liquid under a wide range of temperatures from  $-39$  to plus  $360$ . It remains unchanged in dry air, oxygen, nitrous oxide and carbon dioxide, but in damp air it slowly becomes coated with a film of mercurous oxide which is not particularly important when used in a tube head. Mercury remains unattacked by dilute sulfuric acid and hydrochloric acid when concentrated has only slight action upon the mercury. This property, its complete insolubility in acids, makes mercury an excellent element for use in the head end of the tube because it is completely non-toxic in its metallic form. Reviewing the physical

properties of mercury, we find its lability, marked motility, and cohesive power as being the most desirable features for its use in the head of an intestinal decompression tube, and its non-toxicity and weight as being of secondary importance.

To utilize all these physical properties of mercury to their best advantage, it is necessary that the mercury be placed in a bag that will permit a free range of motion. We must not limit the free play of the mercury in the balloon if we are to utilize these most desirable properties. For this reason, we designed a tube (Fig. 3) which permits the maximum utilization of all the physical properties of metallic mercury and not merely the effect of gravity upon its weighted mass. One notes in examining Figure 3 that the ample balloon at the

terminal end of the single lumen tube permits a "free-flow" of the metallic mercury.

With the mercury trapped in a balloon which permits it to flow freely, it is only necessary to place the patient into positions so that the mercury will always have an opportunity to flow downhill or from side-to-side in order to secure the rapid passage of such a tube far down the gastrointestinal tract. It must be remembered that the tube will not run uphill.

When we make the statement, "the tube will not run uphill" we assume that there is no peristaltic activity pushing it along. If the stomach is in tone and peristaltic waves are present, such a tube will rapidly pass down the gastrointestinal tract without any further ado. However, since we use the tubes in all types of intestinal distention many of the patients either have no peristaltic waves or those that are present are in the reverse direction. In such cases, the maximum utilization of all the physical properties of the mercury and a knowledge of anatomy which permits us to maneuver the patient about so that the part to which the tube head is to go into will always be downhill, helps tremendously in securing the downward passage of the intestinal decompression tube.

In inserting a tube of this type into the nose, if the head of the patient is hyperextended with the patient on his back, the nasal passage runs downhill so that the tube readily drops into the nasopharynx. Then, sitting such a patient up and a drink of water results in the balloon and tube dropping into the stomach. From this point on, a knowledge of certain fundamental anatomical facts is of great value.

When the patient lies flat on his back, the fundus of the stomach comes to lie posterior to the antral portion. As a result, if the tube is passed and the patient lies quietly on his back, the weighted head of the tube would drop into the pouch of stomach in the left paravertebral gutter where the fundus comes to lie. Motion of the patient and putting the pylorus (apex

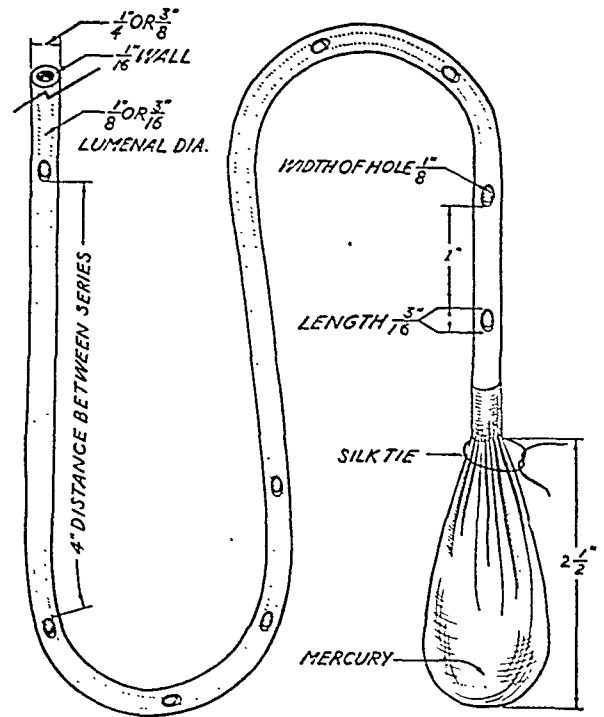


FIG. 3. In the Cantor tube the loose balloon is applied to the end of the tube. This permits a "free-flow" of mercury and permits the utilization of all the physical properties of the mercury. It is the mobility, the lability and marked cohesive power of the mercury and the motion of the patient that carries this tube down and not merely the effect of gravity upon a weighted mass, although this latter effect is also utilized to its best advantage.

of the stomach funnel) in a position so that it will be downhill readily causes the tube to pass through the pylorus. To accomplish this turning the patient on his right side makes the pylorus assume a downhill position. Now if we bear in mind the fact that the first portion of the duodenum is an ascending limb (uphill), it becomes desirable to elevate the foot of the bed twelve inches in order that this limb become downhill.

The second portion of the duodenum runs downward. To utilize this anatomical fact, we lower the foot of the bed and put the patient up on a backrest. The third portion of the duodenum runs transversely from right to left. Turning the patient on his left side would result in the tube head running down the incline. From this point on, motion of the patient and the free flow of the mercury in the tube head readily carries the tube downward. We encourage these patients to move freely. The emphasis

on early ambulation and motion in bed in recent years has demonstrated its great value in preventing vascular, pulmonary and gastrointestinal complications. Utilizing the effect of motion of the patient upon a freely flowing metal such as mercury at the head end of an intestinal decompression tube, great success in its passage has resulted.

#### CONCLUSIONS

1. The physical properties of mercury that make it useful in the "head" of an intestinal decompression tube are mobility, lability and great cohesive power, as well as its complete lack of toxicity. The weight of the mercury, although helpful, is not the most desirable property.

2. To utilize all the desirable physical properties of mercury as a propulsive mechanism, a single lumen tube with the balloon free and ample at the end of the tube, must be used.

3. Motion of the patient not only prevents complications but also aids immeasurably in securing downward passage of the tube.

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# EARLY DIAGNOSIS IN RADICAL RESECTION OF CARCINOMA OF THE LOWER ESOPHAGUS\*

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THE only method of treatment of carcinoma of the lower esophagus or of the fundus of the stomach invading the cardia that has given some real hope of cure is transthoracic radical resection. Probably no one has reported extensive enough personal experiences with radical resection to conclude as to the ultimate value of the operation. However, in reviewing over one hundred cases which have already appeared in the literature by Adams and Phemister,<sup>1</sup> Phemister,<sup>2</sup> Churchill and Sweet,<sup>3</sup> Sweet,<sup>4</sup> Ochsner and DeBakey,<sup>5</sup> Clagett<sup>6</sup> and others, one gains the idea that in certain cases it has been demonstrated to be the best method of palliation. It does give hope of cure, although it is too early to establish its exact value from the standpoint of curability. Nevertheless, in reviewing the reported cases, one gains the impression that the percentage of cures will be disheartening.

The principal reason for this poor outlook is that patients often come to our hospital in the ancient stage of the disease, so that the local and general conditions frequently make them poor subjects for resection. On the other hand, one also not infrequently notes the relative ease with which some of these patients convalesce after resection, only to die a few months later from metastasis. The ultimate high fatal issue would seem to be determined more by the late diagnosis and late resection of the diseased esophagus than by the manner of execution of the modern operation. The preoperative, anesthesia, operative and postoperative technics have been largely mastered in recent years, so that the hospital morbidity and mortality have progressively decreased to within reasonable limits. We believe

that the most important factors in curing patients with carcinoma of the lower esophagus would be an improvement in the early diagnosis and then early radical resection of this diseased area.

The problem of early diagnosis of carcinoma of the esophagus is often difficult and very much similar to the problem of early diagnosis of cancer occurring in other inaccessible organs. There are at the moment at least four outstanding factors which lead to too late radical surgical intervention. These can, perhaps, be best emphasized by a review of a few illustrative cases:

## CASE REPORTS

CASE 1. R. D., No. 454595—epithelioma of the lower esophagus: The author removed the specimen (Fig. 1) transthoracically from a man of sixty-three years, who had a so-called palliative gastrostomy four months following the onset of symptoms of esophageal obstruction. At the time of gastrostomy the patient was still in good general condition. Eight months later, after leading a very unpleasant existence with the gastrostomy he came to University Hospital claiming that he would rather die than live longer with the opening in his stomach. He was greatly emaciated, having lost more than 70 pounds in body weight. After careful preoperative preparation, the lower 3 inches of esophagus and about half of the adjacent stomach were removed. (Fig. 1.) Mediastinal lymph nodes which could be seen were the seat of metastasis and were removed. The epithelioma had already invaded the gastrosplenic ligament to adhere to the spleen so that splenectomy (Fig. 1) was necessary. Postoperatively, the patient had no difficulties with the anastomosis and was eating a regular diet satisfactorily by the twenty-first day. The gastrostomy opening was closed on the forty-

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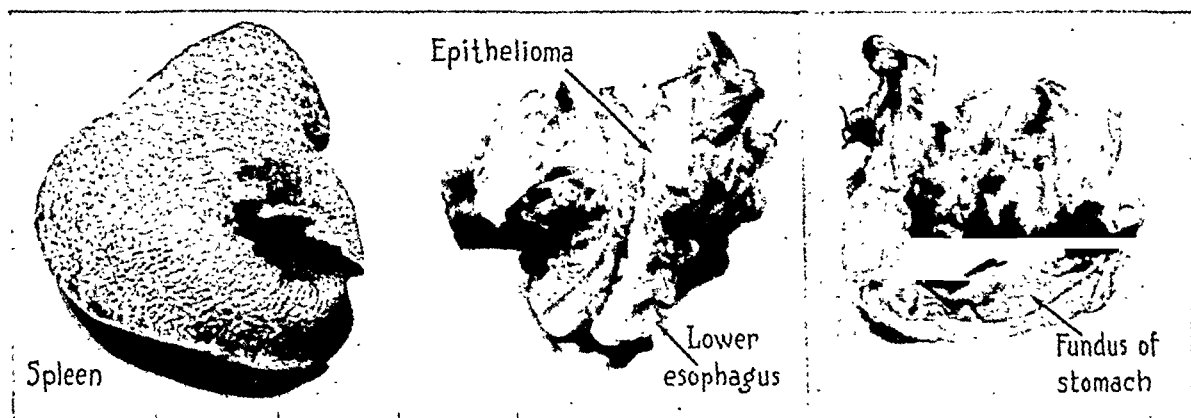


FIG. 1. Note the extensive involvement of the fundus of the stomach by epithelioma which originated in the lower esophagus. The spleen was removed because it was adherent to the cancerous mass.

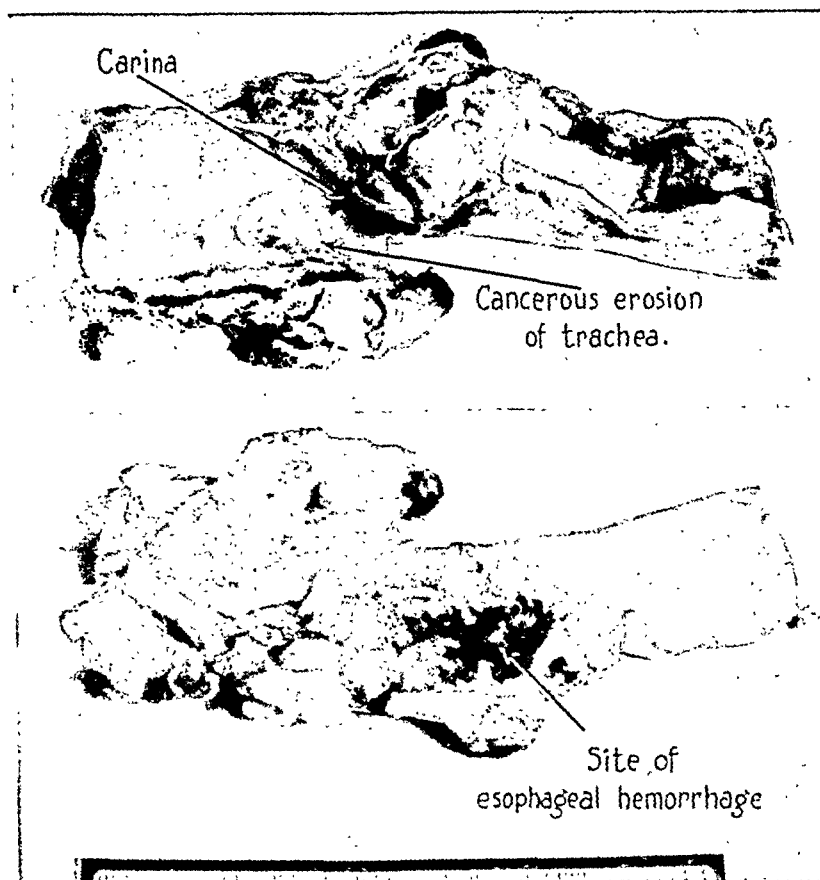


FIG. 2. Upper: Note the squamous cell carcinoma which eroded the esophagus just above the carina. Lower: Note the dark area of the esophagus from which fatal hemorrhage occurred probably due to erosion of a bronchial artery at the bifurcation of the trachea.

fifth day. This patient died suddenly at his home in Toledo, Ohio, over three months following resection. Autopsy was not obtained, so that the exact cause of death was not learned.

*Comment.* There are probably too many surgeons who are still doing so-called pal-

liative gastrostomies without even considering the modern radical operation. This constitutes a factor which leads to delay in resection or more frequently to complete denial to the patient of the benefits of the resection operation. Gastrostomy for carcinoma of the esophagus as

we now know, and as is brought out by this case, is frequently more brutal than palliative.

**CASE II.** H. L., No. 456523—epithelioma of esophagus: This necropsy specimen (Fig. 2) was removed from a man of forty-eight years of age who complained principally of severe dysphagia dating back only four weeks prior to esophagoscopy. Biopsy then revealed a squamous cell carcinoma of the esophagus. Exploratory thoracotomy was done by someone else less than six weeks following the first symptoms. At that time the cancer had already invaded the left recurrent laryngeal nerve and had become densely adherent to the mid-portion of the arch of the aorta. The case was classed unresectable. Palliative gastrostomy was later done. The patient lived a miserable life and died of massive hemorrhage four months following onset of symptoms. Examination of the specimen revealed erosion of the trachea and an area from which fatal hemorrhage occurred. (Fig. 2.)

**Comment.** Obviously, no one knows the answer to early diagnosis of this type of so-called silent carcinoma of the esophagus in which overt signs and symptoms first appear late in the course of the disease. There is now no known way to detect early the existence of such a cancer in the body, let alone its localization in such an inaccessible place as the esophagus. The so-called periodic examination which has proven so successful in the discovery of early cancer of certain more easily accessible regions, such as the cervix uteri, does not yet seem feasible to disclose so-called silent lesions of other organs, such as those of the stomach and esophagus. With our present knowledge of the cancer problem, early diagnosis of these cases will remain rather a remote possibility.

**CASE III.** C. G., No. 455467—adenocarcinoma of fundus of stomach invading the cardia: The patient from whom this specimen (Fig. 3) was removed transthoracically was fifty-seven years of age and of more than average intelligence. However, he treated lightly the slightly annoying substernal discomfort and the slight hold up in the passage of food from the esophagus

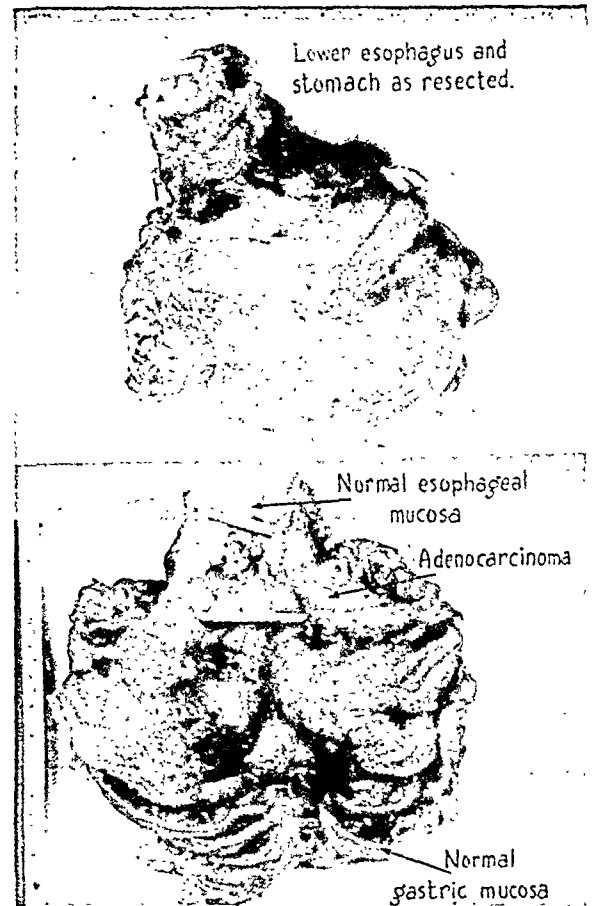


FIG. 3. Note the normal esophageal mucosa above and the normal gastric mucosa below this adenocarcinoma of the fundus of the stomach which invaded the lower esophagus.

into the stomach which he experienced for twelve months. After one year, the dysphagia had become severe enough for the patient to seek the aid of his local physician who in turn referred him to an internist. A diagnosis of spasm of the cardia was made following fluoroscopy during barium swallow. Esophagoscopy was not done. Only after a delay of another eight months, during which tincture of belladonna in various amounts was administered and without relief, was the patient referred to a surgeon. Esophagoscopy then revealed a stenosing lesion of the lower esophagus. Biopsy disclosed adenocarcinoma. The lower 3 inches of the esophagus and the upper half of the stomach were removed along with mediastinal nodes which were the seat of metastasis. The postoperative course was uneventful. The severe interscapular pain which required narcotics before operation soon disappeared. X-ray showed typical findings suggestive of carcinoma of the lower esophagus. (Fig. 4.) Postoperatively, the stomach filled rapidly and there was no hold up of barium in the esophagus as was revealed





FIG. 4. Roentgenography showed typical findings suggestive of carcinoma of the lower esophagus, as is seen on the left. Postoperatively, the stomach filled rapidly and there was no hold-up of barium in the esophagus as was revealed by fluoroscopy and by the other x-ray films which are shown.

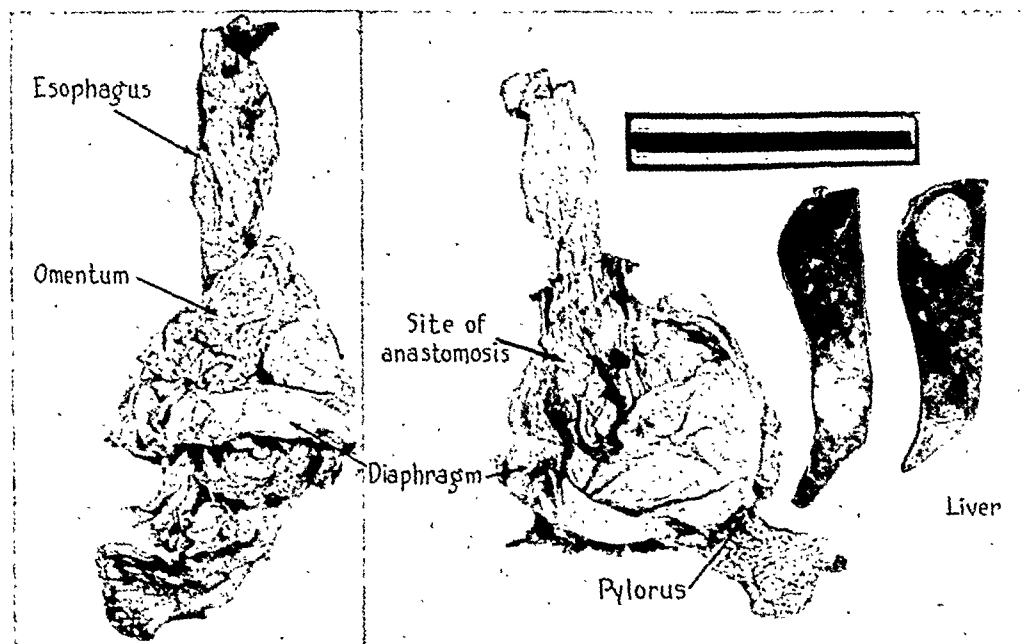


FIG. 5. The omentum adhered well about the site of anastomosis. The diaphragm produced no stenosis and was well attached to the stomach. The area of anastomosis was well healed without gross or microscopic evidence of local recurrence of the tumor. There was no evidence of leakage or stenosis. The liver was the seat of extensive metastasis.

by fluoroscopy and by the x-ray films shown in Figure 4. Three and one-half months after operation, the patient returned to University Hospital for a routine follow-up. He was exceedingly happy to be able to eat normally after about two years of distress. He gained 12 pounds in body weight. On the day he was to be discharged to attend a football game, he developed chills and fever, prostration, jaundice and died within four days with extensive carcinomatous involvement of the liver. The omentum adhered well about the site of anastomosis. (Fig. 5.) The diaphragm produced no stenosis and was well attached to the stomach. The area of anastomosis was well healed without gross or microscopic evidence of local recurrence of the tumor. The liver was the seat of extensive metastasis. (Fig. 5.) This case again empha-

sizes that early diagnosis is one of the essentials to the success of the resection operation.

*Comment.* There is no doubt but that more vigorous education of the public concerning carcinoma of the esophagus is needed, with emphasis that now we have an operation that offers hope of cure when treatment is instituted early. If people are taught to consult their physician early for treatment of minor ailments, the opportunity to discover early cancer of the esophagus will also be enhanced.

The fourth factor which constitutes too little use of esophagoscopy, has been pointed out for years by Drs. Chevalier and Chevalier L. Jackson,<sup>7</sup> and can-

not be too vigorously reemphasized. Today, there are probably still too few esophagoscopies done rather than too many. This procedure should be done more frequently in patients, particularly over thirty, who present relatively minor abnormalities in the sensation of swallowing or symptoms such as vomiting, vague substernal discomfort, vague chest pain, cough or hoarseness which are otherwise unexplained.<sup>8,9</sup> One should be conscious of carcinoma of the esophagus long before some patients present dysphagia as a symptom and even if they never refer to pain. Whether roentgen investigation during the barium swallow is positive or negative for this disease, the suspected patient should be subsequently studied by esophagoscopy. Esophagoscopy and biopsy should be later repeated as often as necessary after the first report of failure to find carcinoma.

There is now reason to believe that earlier preoperative differentiation between malignant and benign lesions of these surfaces will prove more frequent by doing surface measurements of radioactivity<sup>10</sup> by a Geiger-Mueller counting tube applied through a scope such as an anoscope or esophagoscope<sup>11</sup> an adequate time following the administration of a radioactive substance such as radiophosphorus in tracer dose. At any rate, although a positive tissue diagnosis is desirable preoperatively, we believe that exploratory thoracotomy is necessary in a certain number of suspected cases in which the biopsy is negative in order to conform or rule out the presence of esophageal carcinoma. In this way certain cases can be detected and resected when the lesion is still easily removable and metastasis has not yet occurred.

#### SUMMARY

1. There are at the moment at least four outstanding factors which lead to too late radical surgical intervention in treatment of carcinoma of the lower esophagus. Too many surgeons are probably still doing

so-called palliative gastrostomy without considering the modern radical operation. "Silent" carcinoma of the esophagus in which overt signs and symptoms first appear late in the course of the disease is a second factor. Lack of education of the public concerning the early signs of cancer of the esophagus is a definite factor. Too little use of esophagoscopy and exploratory thoracotomy constitute a fourth factor which leads to late diagnosis of cancer of the esophagus.

2. Earlier diagnosis and early radical resection will advance us one step nearer to a more frequent cure for cancer of the esophagus. However, we realize that the esophageal cancer problem may not be satisfactorily solved until methods of prevention and/or of cure for advanced cancer and its metastases are found.

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# GRAFT FIXATION BENEATH TUBED PEDICLE FLAPS\*

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IN the correction of surface defects of the leg and foot, it is often preferable to employ tubed pedicle flaps from the

provide adequate pressure and immobilization to ensure good takes of such grafts without at the same time compromising



FIG. 1. The stay sutures which reduce the size of the donor defect have been inserted, tied and the ends left long.

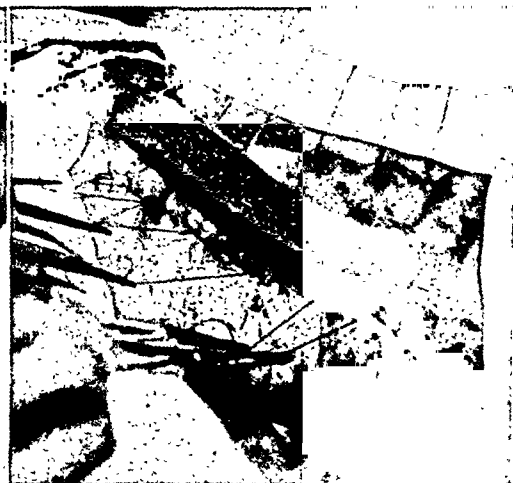


FIG. 2. The donor area has been covered by a single thick split skin graft taken from the opposite thigh. Note the guy sutures opposite each stay suture.

thigh rather than from the abdomen. The chief advantage of the thigh flap in these situations is its original proximity to the defect to be covered. This obviates the necessity for an intermediate carrier, such as the wrist in abdominal flaps, thus reducing the number of stages in the entire procedure, and allows the patient a more comfortable position in immobilization during the final transfer of the flap. A disadvantage of the thigh flap is, that unlike the abdominal flap it is usually impossible to close the donor site beneath the tube by primary suture. An attempt is usually made to cover this defect by the application of a split thickness graft, in order to avoid infection and thrombophlebitis, to reduce dressing and nursing care to a minimum and to provide early ambulation. Difficulty is commonly encountered in applying a dressing which will

the overlying tube. Indifferent success is usually expected and obtained with such grafts. One method of circumventing this obstacle is a time wasting three-stage procedure involving elevation of the flap, interposition of the split thickness graft between the flap and the donor site, and final elevation and tubing of the flap at the third stage.

We propose to describe a one-stage method which has been entirely satisfactory in eight consecutive cases.

## METHOD

In each of eight cases a tubed pedicle flap was fashioned from the medial aspect of the thigh and the donor area completely covered immediately by the application of a single split thickness skin graft cut from the opposite thigh with the Blair-Brown knife. Prior to application of the graft, the

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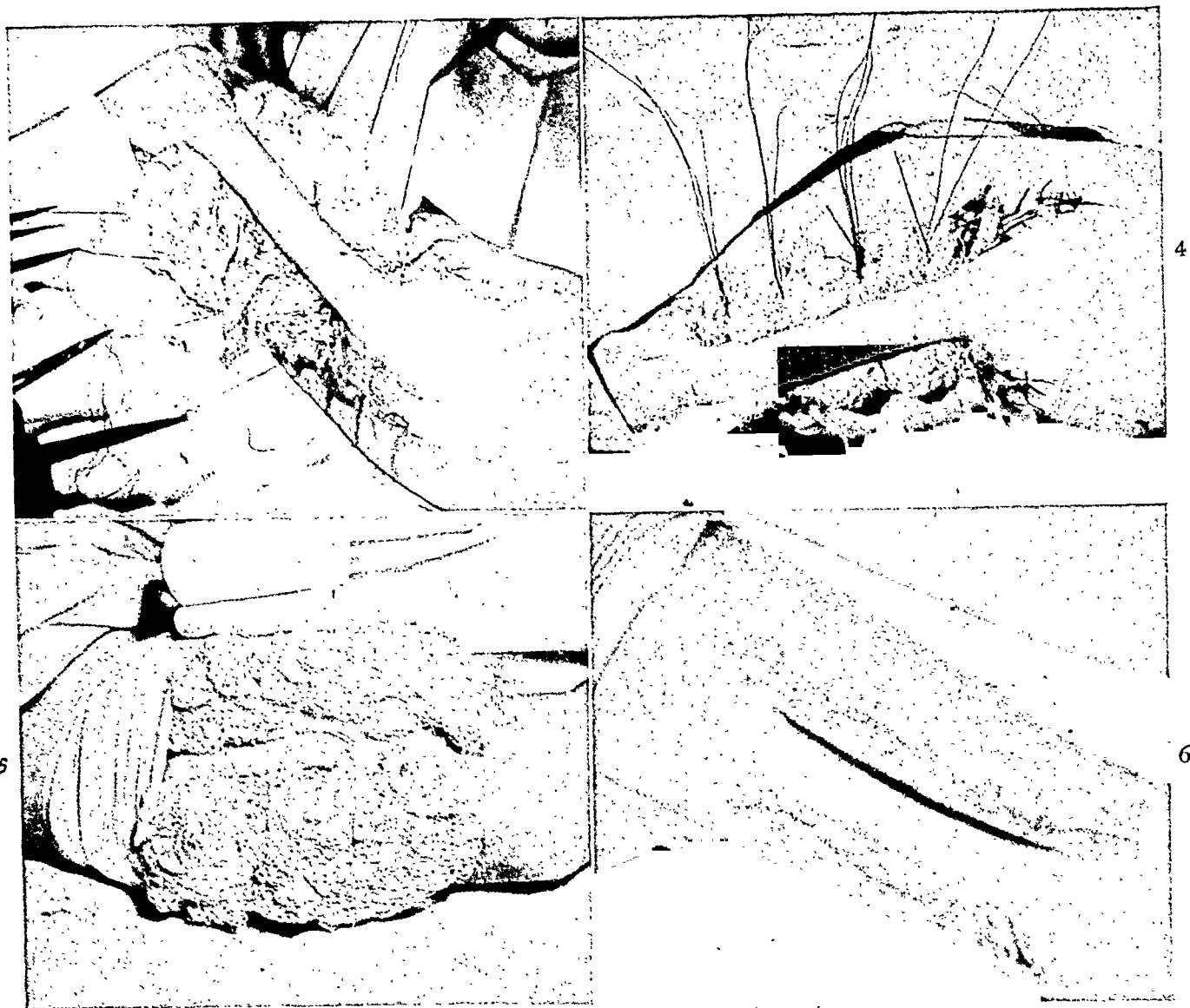


FIG. 3. The skin graft has been dressed with fine mesh vaseline gauze, the edges of which have been cut over each guy and stay suture and the stent of machinist's waste has been applied beneath the tube.

FIG. 4. Opposing sutures have been tied firmly over the stent beneath the tube.

FIG. 5. Voluminous rolls of machinist's waste placed on either side of the tube serve to protect and immobilize the tube.

FIG. 6. Showing the appearance of the skin graft and tube on the twelfth day.

width of the donor area was reduced by a row of end-on mattress sutures placed about 1 inch apart, the ends of which were left about 4 inches long after tying. Next, an equal number of guy sutures was symmetrically placed in the opposite edge of the defect and were also left long. (Fig. 1.) The skin graft was then applied to the reduced defect and sutured in place. (Fig. 2.) A single layer of fine mesh vaseline gauze, large enough to overlap the defect by 1 inch, was carefully applied to the graft beneath the tube and cuts were made with scissors from the edge of the gauze to the margin of the graft over each stay and guy

suture. Next, a stent-type dressing of machinist's waste, not so large as to cause tension on the tube by elevation, and carefully adjusted so as not to interfere with the vascular supply of the pedicle, was applied over the vaseline gauze and beneath the tube. (Fig. 3.) The mattress and guy sutures were then tied over the waste stent beneath the tube at the proper tension. (Fig. 4.) The cuts made in the edge of the vaseline gauze allow this to be done without disarranging the application of the vaseline gauze to the graft margin. The stent was then covered with a strip of vaseline gauze to protect the suture line in

the tube itself, and the tube was further protected by means of voluminous rolls of machinist's waste on either side. This immobilized the tube and protected it from undue compression. Next, the dressed and protected tube was firmly but not too tightly wrapped with a 5 yard gauze roll which enveloped the entire thigh, and which was fixed in place by adhesive strips. (Fig. 5.)

#### COMMENT

In our brief experience, this type of dressing has the following advantages:

1. It provides firm fixation, immobilization and sufficient pressure on the graft.
2. It ensures protection and immobilization of the tube.
3. Cutting of the superficial gauze dressing makes the tube easily accessible for frequent inspection without disturbing the stent dressing on the graft.

The stent dressing is left undisturbed for

six or seven days, at the end of which time the sutures holding the stent in place are cut and likewise the sutures in the graft itself are cut and removed. It is important to leave the end-on mattress sutures in place for an additional four or five days. If this is not done, the area of the donor site will re-expand, pulling away from the edges of the graft, leaving a circumferential raw area between the graft and the skin edge. Fig. 6 shows the results obtained with this method.

#### SUMMARY

1. The difficulties of applying adequate pressure dressings to split skin grafts applied to the donor areas beneath tubed pedicle flaps have been described.
2. A satisfactory and efficient pressure dressing of the stent-type is described, which has resulted in complete takes of grafts beneath tubed pedicle flaps in eight consecutive cases.



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# Case Reports

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## CARCINOMA OF THE COLON IN CHILDHOOD AND ADOLESCENCE

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IT is becoming increasingly evident that the incidence of malignant neoplasia in childhood and adolescence is much more common than has been appreciated in the past. Not only is this true of sarcomas, which are admittedly common in youth, but epithelial malignancies are of sufficient frequency to warrant their consideration in differential diagnosis of childhood diseases. Only a brief perusal of recent literature convinces one of the frequency of carcinoma of the breast, ovary and liver in young individuals. This is also true of carcinoma of the gastrointestinal tract and especially of carcinoma of the large bowel. Bacon,<sup>3</sup> in a series of 1,995 collected cases, estimated the incidence of cancer of the sigmoid, rectum and anus below the age of thirty at 5.4 per cent. Rankin,<sup>42</sup> in a series of 1,452 cases, found the incidence below this age to be 3.85 per cent. That cancer of the rectum is not an uncommon lesion in patients under twenty years of age is re-emphasized by Bacon<sup>3</sup> who cites ninety-four proven cases collected from the literature.

Cancer of the colon in children, as in adults, is less frequent than is cancer of the rectum and rectosigmoid, but occurs much more frequently than is generally realized. A recent case of histologically proven carcinoma of the right half of the transverse colon, which was successfully treated by resection, served as an impetus for a review of the literature. This revealed adequate evidence of the fallacy of excluding colonic neoplasia in children and adolescents on the basis of age alone. (Table 1.)

### CASE REPORT

Case No. T-45-169121. W. B., a thirteen-year old colored male, was admitted to the Charity Hospital of Louisiana at New Orleans on March 11, 1945, and was discharged April 25, 1945. The case was diagnosed as adenocarcinoma of the right half of the transverse colon, acute appendicitis and amebiasis. The patient complained of pain in the right abdomen. The onset of the present illness, was March 5, 1945, six days before admission. The patient began to experience intermittent, cramping pain in the lower abdomen. Two days after the onset of illness, he began to vomit with each paroxysm of pain. Vomiting was regurgitant and not projectile; vomitus contained no blood and was not feculent. There had been no bowel movement since the onset of the present illness. He noticed that his abdomen was becoming distended. The patient gave no history of previous operations, and denied ingestion of persimmons, indigestible foodstuff and passing worms per rectum.

A review of symptoms revealed that the patient had not suffered with headaches or dizziness and only occasionally had upper respiratory infection. He never had pain on exertion, postural dyspnea, pedal edema, cough, sputum or hemoptysis. He experienced an occasional bout of indigestion two to three months previous to examination. These episodes were apparently similar to his present illness but were milder in character. There were no enuresis, hematuria, penile lesions or discharge, hesitancy, dribbling and no joint or muscle weakness.

Physical examination revealed the temperature to be 100° F., pulse rate, 114; respiration, 26; blood pressure, 108/60. He was a well developed, somewhat undernourished colored

TABLE I  
CARCINOMA OF COLON IN CHILDREN SIXTEEN YEARS OF AGE AND UNDER

No.	Year	Authority	Age	Sex	Location	Microscopic Diagnosis	Operation	Survival
1	1865	Steiner <sup>43</sup>	9	M	Sigmoid	Carcinoma	None	Died of obstruction
2	1872	Leijer <sup>19</sup>	9	M	Sigmoid	Carcinoma	Artificial anus	Died 11 days post-operatively
3	1878	Spanton and Frost <sup>47</sup>	12	F	Cecum	Encephaloid carcinoma	None	2 months—died of obstruction
4	1883	Maydl <sup>13</sup>	12	F	Cecum	?	?	?
5	1883	Maydl <sup>13</sup>	13	M	Cecum	?	?	?
6	1885	Clar <sup>8</sup>	3½	M	Sigmoid	Carcinoma	?	?
7	1893	Burger <sup>6</sup>	15	M	Ascending colon	?	Colostomy	Died soon postoperatively
8	1895	Mayo-Roberson	14	F	Ascending colon	Columnar epithelioma	Resection	In good health 6 mo. later
9	1897	Garrard <sup>14</sup>	12	M	Sigmoid	Colloid carcinoma	Resection	Over 6 months
10	1897	Petroff <sup>35</sup>	16	M	Hepatic flexure	Carcinoma	Resection	Classified as "cure"
11	1898	Nothnagel <sup>29</sup>	12	M	Cecum	?	?	?
12	1898	Israel <sup>15</sup>	13	M	Splenic flexure	Colloid carcinoma	?	?
13	1900	Paultauf <sup>24</sup>	12	F	Sigmoid	Cylindric cell epithelioma	None	Died of obstruction
14	1900	Zuppinger <sup>55</sup>	12	F	Sigmoid	Cylindric cell epithelioma	None	Death
15	1902	Marsh <sup>21</sup>	15	M	Sigmoid	Columnar cell carcinoma	Resection with anastomosis	Evidence of recurrence 4 mo. later
16	1904	Ruczynski <sup>45</sup>	13	M	Splenic flexure	Cylindric epithelioma	Enterostomy	Died 1st postoperative day
17	1906	Mandelung <sup>22</sup>	13	M	?	?	?	?
18*	1907	Allbutt and Rolleston <sup>3</sup>	10	M	Sigmoid(?)	Colloid carcinoma	?	?
19	1907	Bernouilles <sup>5</sup>	15	M	Sigmoid	Alveolar carcinoma	?	Death
20	1908	Clogg <sup>10</sup>	15	?	?	?	?	?
21	1913	Muralt <sup>25</sup>	13	M	Ascending colon	Colloid cylindrical epithelioma	Appendicostomy	Died 1st postoperative day
22	1913	Parkinson <sup>33</sup>	9	M	Sigmoid	Colloid carcinoma(?)	None	Died
23	1921	Olmsted <sup>22</sup>	14	M	Sigmoid	Adenocarcinoma	Mikulicz resection	Alive 6 mo. post-operatively
24	1923	Mouchet and Baranger <sup>27</sup>	10	F	Splenic flexure	Adeno-epithelioma	?	?
25	1925	Wainwright <sup>51</sup>	11	F	Splenic flexure	Gelatinous carcinoma	Colostomy; enterostomy	Died 2 days post-operatively
26	1925	Ullhorn <sup>50</sup>	3½	M	Sigmoid	?	?	?
27	1926	Clark <sup>9</sup>	16	M	Sigmoid	Carcinoma	Colostomy; biopsy	Died 3 days post-operatively
28	1929	Chajutin <sup>7</sup>	14	F	Cecum	Adenocarcinoma	Incision and drainage of abscess	Died
29	1930	Drinkwater <sup>12</sup>	15	F	Descending colon	Colloid carcinoma	?	8 days survival
30	1931	Rocher and Guerin <sup>44</sup>	11	M	Splenic flexure	Adenocarcinoma	?	Death
31	1933	Walker and Daly <sup>52</sup>	5	M	Cecum	Adenocarcinoma	Palliative resection	Died 2 mo. post-operatively
32	1933	Pouzet <sup>41</sup>	14	M	Ascending colon	Adenocarcinoma	?	3½ months
33	1933	Wakeley <sup>42</sup>	16	M	Ascending colon	Colloid carcinoma	Palliative ileo-transverse colostomy	4 months
34	1935	Pfeiffer and Wood <sup>46</sup>	7	M	Transverse colon	Fibroma with adenocarcinoma	Mikulicz resection	Died on 1st day postoperatively
35	1935	Stuart <sup>43</sup>	15	M	Transverse colon	Carcinoma	?	?
36	1935	Ball <sup>4</sup>	15	F	Sigmoid	Mucoid carcinoma	Exploratory laparotomy	Died 10 days post-operatively
37	1935-1936	Ogilvie <sup>21</sup>	13	M	Cecum	Mucoid carcinoma	Ileo-transverse	43½ months
38	1937	Warthen <sup>41</sup>	14	F	Transverse colon	Signet ring adenocarcinoma	Palliative obstruction resection	Left hospital alive; no follow-up
39	1938	Webster <sup>55</sup>	9 yr. 9 mo.	F	Sigmoid	Adenocarcinoma	Mikulicz resection	Died of cerebellar metastases 4 yr. later (longest reported survival)
40	1938	MacQuire <sup>21</sup>	15	M	Transverse colon	Adenocarcinoma	Resection of colon and stomach	Left hospital "well" no follow-up
41	1940	Rawls <sup>42</sup>	12 yr. 11 mo.	F	Splenic flexure	Colloid carcinoma	Colostomy; biopsy	5½ months
42	1940	Plehn <sup>42</sup>	9	F	Cecum	?	?	?
43	1941	Pennell and Martin <sup>29</sup>	13½	M	Ascending colon	Colloid carcinoma	Right hemicolectomy	Apparently well 9 mo. postoperatively
44	1941	Laird <sup>11</sup>	14	M	Splenic flexure	Colloid carcinoma	Exploratory laparotomy	30 days
45	1943	Moos and Dittmer <sup>31</sup>	16	M	Transverse colon	Adenocarcinoma	Mikulicz resection	Without evidence of disease 26 mo. later
46	1943	King <sup>14</sup>	12	M	Sigmoid	Colloid carcinoma	Exploratory laparotomy	Died 3 mo. post-operatively
47	1944	Sandes <sup>41</sup>	12	M	Ascending colon	Colloid carcinoma	Resection	Death 7th day post-operatively
48	1946	Johnston	13	M	Transverse colon	Adenocarcinoma	Right hemicolectomy (2 stages)	Alive, without evidence of recurrence, 6 mo. postoperatively

\* Reporting Milne's case, which may have involved rectum instead of sigmoid.

† Personnel communication.

male. He did not appear to be acutely ill. His skin was dry and slightly inelastic, suggesting dehydration. The head was of normal size and shape and the scalp was clean. His vision was good. The pupils reacted to light and accommodation. The patient's hearing was within normal limits. Tympanic membranes were normal with no bulging or hyperemia. There was no discharge or deviation of the nasal septum. His teeth were in fairly good condition with no pyorrhea. The tonsils were not enlarged. The posterior pharyngeal wall was slightly injected. There were no masses in the neck, the thyroid was not enlarged, the trachea not deviated and there were no lymphadenopathy or abnormal pulsations. The chest was symmetrical in outline and there was no flaring of the costal margin.

The lungs were free and equal in expansion. There were no areas of dullness, râles or friction rubs. The heart was not clinically enlarged and there were no murmurs, thrills or arrhythmias. The abdomen was slightly distended. At five to ten-minute intervals, the patient complained of abdominal pain and an oval mass about 6 by 8 cm. appeared in the right lower quadrant. The mass was slightly tender to palpation and tympanitic to percussion. Associated with pain and appearance of the mass were borborygmi—peristaltic rushes. With the disappearance of pain, the mass regressed, leaving a slightly distended abdomen without tenderness or rigidity. No hernias were present. The genitalia were well developed; both testicles had descended. There was good sphincter tone; the prostate was small and there was no mass or tenderness in the cul-de-sac. Reflexes were physiological.

Laboratory data were as follows: 3.5 red blood cells per cu. mm., 10,900 white blood cells per cu. mm. with 81 per cent polymorphonuclear leukocytes, 17 per cent lymphocytes and 1 per cent eosinophils. Urinalysis revealed nothing abnormal. No red blood cells were found. Blood chemistry: Urea nitrogen was 10.3 mg. per cent; the Kline and Kolmer tests were negative. An erect plate of the abdomen showed multiple distended loops of bowel with fluid levels.

Provisional diagnosis was low small gut intestinal obstruction due to: (1) ileocecal or ileocolic intussusception; (2) bezoar: (A) foodstuff (especially persimmons), (B) ascaris lumbricoides; (3) inflammatory adhesions (due

to previous appendiceal disease), and (4) hyperplastic tuberculosis of cecum or ascending colon.

Upon admission to the hospital, gastroduodenal suction by Wangenstein apparatus was begun. The patient was given 500 cc. of whole blood and a liter of 5 per cent dextrose in normal saline, after which he was taken to the operating room for exploratory laparotomy.

The patient was anesthetized in the dorsal position with vinethene and ether administered by the open drop route. Whole blood was administered during the procedure, which the patient withstood quite well.

The peritoneal cavity was entered through a right rectus muscle-splitting incision about 10 cm. in length. Upon entering the peritoneum, a markedly distended, slightly hypertrophied small bowel was evident. The cecum was identified and proved to be slightly distended; no collapsed small bowel was visualized. Believing the ileocecal region to be the site of the obstruction, a careful search was carried out. No evidence of intussusception or intraluminal masses could be found. The appendix was both retrocecal and retroperitoneal. Believing that previous appendiceal disease may have left sufficient scar tissue to produce obstruction, the appendix was exposed and dissected free. To our surprise, it was acutely inflamed but was not encroaching upon the bowel lumen. An appendectomy was effected, inverting the stump without ligation. Palpation of the colon revealed a napkin ring obstruction of the transverse colon about 4 cm. distal to the hepatic flexure. The operative incision was lengthened superiorly and the mass mobilized. Grossly it was a typical annular carcinoma of the bowel. The regional lymph nodes were diffusely enlarged. There was no evidence of hepatic metastases or peritoneal seeding. It was obvious that a right hemicolectomy would be necessary to remove the lesion and its nodal area. A two-stage procedure was elected because of the obstruction. Accordingly, a side-to-side anastomosis between the terminal ileum 40 cm. from the ileocecal valve and the mid-portion of the transverse colon just distal to the middle colic vessels was done in an aseptic fashion, utilizing quilting cotton sutures. The patency of the anastomosis was determined by palpation. Layer closure of the wound was then carried out after a small rubber dam drain was placed deep to the rectus muscle.





FIG. 1. Photograph of resected specimen. 1, ileocecal valve; 2, lesion.

Postoperatively, the patient was treated with nasogastric suction, parenteral fluids, blood transfusions, etc., for three days, when normal peristaltic sounds could be heard. Progressive diet was begun and was tolerated well by the patient. The drain was advanced daily and the wound healed per primum.

Stool studies revealed the presence of *Endameba histolytica* cysts, raising the possibility of the lesion being an ameboma of large bowel. The typical gross appearance of the lesion was that of carcinoma, however, in spite of the patient's youth. The intestinal amebiasis was treated with diodoquin.

After correcting the mild anemia with multiple transfusions, preparing the bowel with sulfasuxidine, 2 Gm. four times a day, the second operative procedure was done one month later.

Under ethylene and ether vapor anesthesia, the abdomen was re-entered through previous right rectus incision. Numerous veil-like fibrous adhesions were present between the large gut, abdominal wall, liver and gallbladder. These were easily freed by sharp dissection. The anastomosis made at the last operation was intact and functioning. The lateral peritoneal reflection of the right colon was incised and the bowel mobilized medially, carefully preserving the ureter, internal spermatic vessels and retroperitoneal duodenum. A wide wedge of mesentery was then dissected free after the ileocolic and right colic vessels had been ligated next to the superior mesenteric trunks. The ileum and colon were divided with the actual cautery 3 cm. distal to the anastomosis and



FIG. 2. Photomicrograph of lesion in personal case.

aseptically inverted. Careful reperitonealization was then accomplished. The wound was closed in layers with quilting cotton after a rubber dam drain had been placed deep to the rectus muscle.

Postoperatively the patient's progress was without untoward incident and he was discharged from the hospital eleven days later.

The pathological report (by Dr. Charles Dunlap, Professor of Pathology, School of Medicine, Tulane University of Louisiana, New Orleans, La.) is as follows:

**Gross:** The specimen (Fig. 1) consists of a portion of intestine 70 cm. long including 45 cm. of ileum attached to the cecum and 25 cm. of ascending and transverse colon. The serosal surfaces of the intestine are smooth, shiny and pink and appear normal. Numerous small, firm lymph nodes are present in the mesentery. The mucosa of the ileum and cecum is pink and velvety and appears to be normal. In the colonic segment, 10 cm. from the end of the specimen there is a firm mass of pale grey tissue extending 4 cm. in the long axis of the intestine, extending into the intestinal wall and protruding into the lumen so as to produce almost complete obstruction. In the central portion of the mucosal surface of this mass the mucosa is ragged and superficially ulcerated.

**Microscopic:** In a section (Fig. 2) taken through the mass it is seen that the normal mucosal glands are missing. The mass is composed of dark staining epithelial cells which form irregular gland-like spaces of varying sizes

## AGE INCIDENCE

### Carcinoma of Colon in Childhood and Adolescence

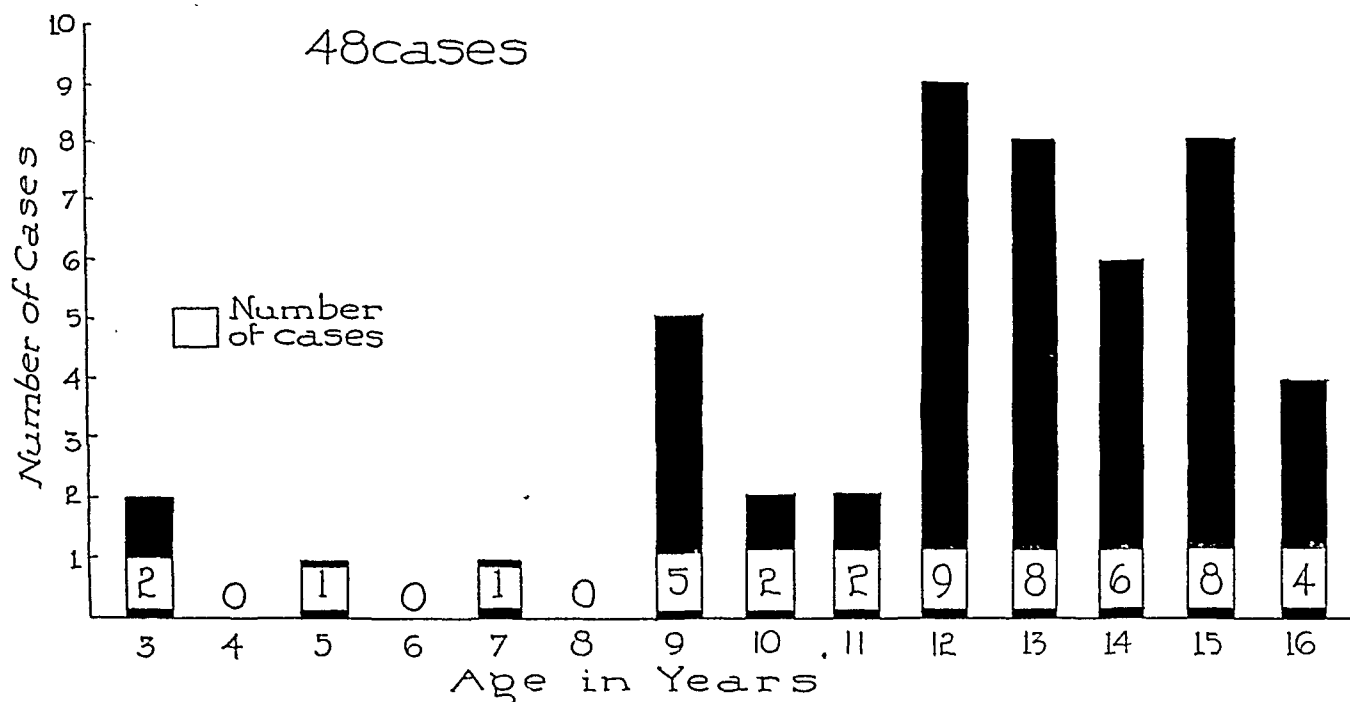


FIG. 3. Age incidence in collected cases.

and shapes. In some regions a few epithelial cells are growing as solid cell cords without lumen formation. The cells show only moderate variations in size. Occasional mitotic figures are present. A few cells contain clear cytoplasmic vacuoles but there is no evidence of extensive mucus production. These epithelial growths extend through the muscularis mucosa and invade deeply into the main muscular coats of the bowel.

About the borders of the growth there is extensive fibrosis and a considerable infiltration of lymphocytes and macrophages. Several collections of foreign body giant cells are present in the unflammatory mass which partially surrounds the main growth. There is no evidence of invasion of neoplastic cells into lymphatic or blood vessels.

Twenty-four lymph nodes from the mesentery show varying degrees of edema and inflammatory hyperplasia but there is no evidence of metastatic neoplasm.

Diagnosis: Adenocarcinoma of the colon.

Follow-up in the out-patient department showed that the patient returned to excellent health rapidly with a 45 pound weight gain in four months. He was completely asymptomatic and carried out normal activities six months postoperatively. Sigmoidoscopic and roentgenologic examinations were negative for polypi at the last clinic visit.

#### ANALYSIS OF REPORTED CASES

Review of the literature reveals forty-seven cases of proven carcinoma of the large bowel, excluding rectum and rectosigmoid, in patients sixteen years of age and under. (Table I.) As so many of these cases terminate unsatisfactorily and hence are less likely to be reported, this by no means represents a true incidence of colonic carcinoma in childhood and adolescence. Such a review does stress the occurrence of malignant neoplasia of the bowel in patients younger than the so-called "cancer age" and calls for a consideration of this disease entity in the young.

**Age.** The youngest patients in this group were Clar's<sup>8</sup> patient who was three and one-quarter years of age, and Ullhorn's<sup>50</sup> three and one-half year old patient. Ahfeld<sup>1</sup> cites the occurrence of a carcinoma of the rectum in a newborn monster. Reference to Figure 3 discloses an appreciable increase in colonic carcinoma after the age of nine.

**Sex.** As shown in Figure 4, 70 per cent of the patients were males. This is in agreement with the sex incidence of colonic cancer in adults; most authors state that

## SEX INCIDENCE

### Carcinoma of Colon in Childhood and Adolescence



FIG. 4. Sex incidence in reviewed cases of carcinoma of colon in childhood and adolescence.

men are affected more commonly than women. Rankin<sup>42</sup> has noted a predominance in males in the ratio of approximately 2:1.

*Site of New Growth.* Carcinoma of the colon shows essentially the same variance of location as is found in adults. (Fig. 5.) Pemberton and Dixon,<sup>38</sup> in reporting a series of 1,293 cases of carcinoma of the colon, excluding rectum and rectosigmoid, found 37 per cent in the sigmoid and 16 per cent in the cecum. Lockhart-Mumery,<sup>20</sup> in a study of 560 cases, found 50 per cent in the sigmoid, 22.5 per cent in the cecum and ascending colon, 21.6 per cent in the transverse colon with flexures and 5.3 per cent in descending colon. Thus, the same unexplained increased frequency of carcinoma in the pelvic colon is shown in children as in adults.

*Incidence of Acute Obstruction.* In adults, the frequency of acute complete obstruction associated with carcinoma of the colon varies from 16 to 35 per cent. It was not feasible to determine this frequency in children from the information available, but it would seem that conservatively,

at least 70 per cent of the reported cases of carcinoma in children were first seen in the stage of acute obstruction. Frequent comment was made on the marked distention and hypertrophy of the small bowel associated in children with obstruction of the colon, suggesting the incidence of competent ileocecal valves in children to be appreciably less than the 61 per cent found by Dennis<sup>11</sup> in adults.

*Prognosis.* Only a glance at the results obtained in the reported cases depicts the poor prognosis of colonic carcinoma in children. This is partially explained by the more serious import of malignant disease in the young. Yet the most important single factor in this poor prognosis is the failure to institute early and adequate therapy, reflecting a failure to appreciate the occurrence of malignancy in the young. Some of the deaths were due to poor surgical judgment, i.e., resecting local lesions in the face of acute obstruction. The longest reported survival is the case reported by Webster<sup>55</sup> in which the child succumbed to a cerebellar metastasis four years following resection of the sig-

## LOCATION OF LESION

### Carcinoma of Colon in Childhood and Adolescence 46 cases

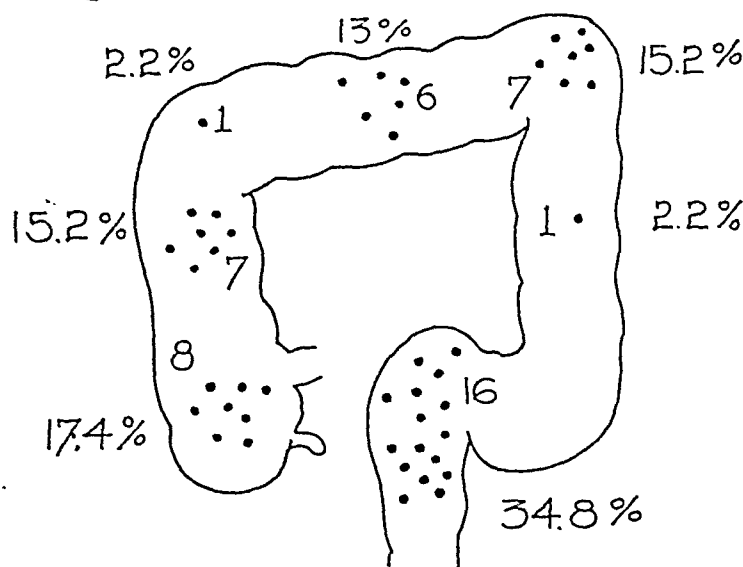


FIG. 5. Variation of site of lesion in collected cases.

moid for adenocarcinoma. It will be noted, however, that the prognosis has improved considerably in the past decade.

*Pathology.* In thirty-nine cases an accurate microscopic diagnosis is given; in seventeen or 43 per cent, the diagnosis was colloid or gelatinous carcinoma. The incidence of colloid carcinoma of the colon is therefore much higher in children than in adults. (Fig. 6.) In a series of 3,202 cases, Rankin<sup>42</sup> states the incidence of colloid carcinoma of the colon and rectum to be 4.9 per cent, i.e., one-tenth as frequent as is found in children. As will be recalled, colloid carcinoma tends to grow slower and metastasize later than other adenocarcinoma without colloid. Broders defines colloid carcinoma as adenocarcinoma with a tendency to differentiate to the extent that a mucus-like secretion is found. Ewing<sup>13</sup> describes colloid carcinoma as spreading over a considerable length of intestine producing bulky tumor masses which extensively replace the original tissue. Growth of mucoid carcinomas is chiefly by expansion and permeation, thereby making transplants common. In general, colloid carcinoma has a higher eventual mortality but usually shows greater longevity with later metastases. Occasionally, pseudomyxoma peritonae,

or accumulation of gelatinous bodies resembling tapioca within the peritoneum, may be associated with colloid carcinoma of the colon. Unfortunately, in most of the recorded cases there is no mention of the presence or absence of associated polyposis.

*Diagnosis.* There is no fundamental difference between colon malignancies occurring in children and those in adults, except for shorter duration of symptoms due to more rapid growth of the tumors in the younger age group. Unfortunately, the majority of cases in this collected series were first actively treated after acute intestinal obstruction had supervened. Allowing the disease to progress to such advanced stage without diagnosis reflects the obscure early symptomatology of large bowel neoplasia in both adults and children. Even more pointedly, however, it reflects the tendency of many practitioners to exclude the possibility of cancer of the colon on the basis of age alone. Nothing could be more incorrect.

As is repeatedly emphasized, the colon consists embryologically, physiologically, and to a certain extent anatomically of two distinct components: (1) the right colon extending from the cecum to the mid-transverse colon, which shares the

## Incidence of Colloid Carcinoma

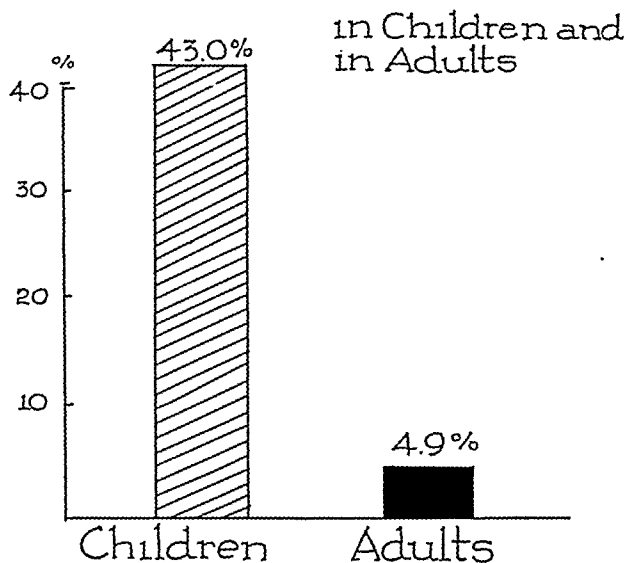


FIG. 6. Depicts the marked difference in relative frequency of colloid carcinoma in children and adults.

physiologic function of absorption with the small gut and (2) the left colon, extending from the mid-portion of the transverse colon to the rectum, which is fundamentally a store house. Such a disparity in function is not surprising when one recalls that the right colon develops with the small intestine from the mid-gut, while the left colon and rectum are formed by the hind gut.

These basic differences influence symptomatology so that two rather distinct clinical types frequently occur. Due to the narrow lumen, more inspissated feces, and greater frequency of annular, napkin-ring type of lesions, carcinomas of the left colon generally present a clinical picture dominated by obstructive phenomena. Change in bowel habit, i.e., progressively increasing constipation due to the encroachment on the bowel lumen by the lesion; diarrhea, due to inflammatory irritation of ulcerations, or less frequently, alternating constipation and diarrhea, are common complaints. Dark to bright red blood in the stools is usually indicative of a lesion distal to the splenic flexure. Gross blood is less frequently seen in lesions of the right colon since it is so well mixed in the stool that its presence is likely to be overlooked. Pain of an inter-

mittent or colicky nature often brings the patient for examination. Tenesmus is infrequent except in low lying sigmoidal lesions.

On the other hand, obstructive symptomatology is infrequent in the right colon, except when cecal neoplasia encroach upon the ileocecal valve and low small gut obstruction is produced. Right colon lesions often manifest themselves by the presence of a tumefaction or anemia. In approximately 30 per cent of cases occurring in the younger age groups, a palpable mass is incidentally discovered by the patient or during routine physical examination. A similar percentage fall into the group characterized by anemia with concomitant weakness and easy fatigability. The pathogenesis of anemia is debatable; many attribute it to the absorption of toxins. Certainly every case of anemia in which the cause is not frankly obvious needs a complete work-up to exclude malignancy of the cecum and ascending colon.

Lesions in the colon, either right or left, often present dyspeptic symptoms which are so vague and protean as to make diagnosis impossible on the basis of symptomatology alone. Hence, persistent abdominal discomfort, especially

occurring several hours after meals, anorexia, flatulence, etc., demand careful investigation of the colon. This is best done by combined sigmoidoscopic and roentgenologic examination by barium enema. It should be recalled that these examinations are complementary and one should not be used in lieu of the other.

*Differential Diagnosis.* The differential diagnosis usually rests between diseases which produce varying degrees of intestinal obstruction, those which produce abdominal tumefaction, or both. To be considered are:

1. *Granulomatus lesions of the bowel*, including hyperplastic tuberculosis, regional enteritis or enterocolitis (chronic stage), amebomas, non-specific granulomas, actinomycosis, etc. These lesions, as in adults, simulate colon malignancy very closely in symptomatology, chronicity and roentgenographic studies. Occasionally, one is able to make a diagnosis of granuloma on the basis of evidence of low grade infection: mild fever, leukocytosis, anemia, etc. Evidence of pulmonary tuberculosis increases the likelihood of bowel tuberculosis although the latter may be primary. Draining sinuses or fistulas are more frequently seen in regional enteritis and actinomycosis than in carcinoma. Bacteriologic studies often establish the etiologic factor in actinomycosis and other fungus infections.

2. *Subsiding or chronic pyogenic lesions*, including ruptured appendicitis with abscess formation, ingested foreign bodies with perforation and localization, and less frequently in the young, simple ulcers of the bowel (especially cecum) or diverticulitis with adjacent inflammatory reaction. Such lesions are usually more acute in onset and more progressive in course, and can be excluded by careful examination in the acute phase. Occasionally, an unresolved inflammatory mass may reproduce the exact picture of neoplasia of the colon.

3. *Intussusception*: Ladd and Gross<sup>17</sup> recently emphasized this to be a disease of infancy; 75 per cent of 484 cases oc-

curred in the first year of life, only 2.4 per cent occurred after six years of age. Discovering intussusception after infancy should at once lead to search for an underlying cause: polyp, diverticulum or tumor. In acute intussusception, the diagnosis can usually be made on the basis of paroxysms of abdominal pain, presence of abdominal mass and passage of blood per rectum. On the other hand, chronic intussusception mimics the picture of carcinoma of the colon so closely that it can be distinguished only by barium enema or laparotomy.

4. *Bezoars*: Not infrequently vegetable material becomes compactly moulded together forming a phyto-bezoar; or ingested hair may form a firm bolus or trichobezoar. DeBakey and Ochsner<sup>30</sup> have pointed out that persimmons cause 73 per cent of phytobezoars. Careful questioning about food habits may establish the diagnosis.

5. *Embryoma of kidney (Wilm's tumor)*: This highly malignant neoplasm is one of the most common abdominal tumors encountered in childhood and should be excluded in all cases with abdominal tumefaction. Diagnosis is readily established by careful analysis for hematuria and pyelograms. Obstructive symptoms are not common in Wilm's tumors, in contradistinction to intrinsic lesions of the bowel.

6. *Congenital megacolon*: Hirschsprung's disease may occasionally cause some difficulty in diagnosis, but can usually be excluded on the basis of history of constipation since early infancy and finding a markedly protuberant abdomen with multiple palpable fecal masses. A plain film of the abdomen frequently makes the diagnosis by showing a markedly dilated colon which has a matted appearance due to inspissated feces.

*Treatment.* The treatment of colonic carcinoma in youth is that of colon cancer in adults. Since carcinoma of the large intestine metastasizes less frequently than carcinoma of any other portion of the gastrointestinal tract, good results can be obtained by early diagnosis and radical

surgical extirpation. Due to the general unfavorable course of malignancy in the young, all operable lesions should have especially radical removal since this represents the only chance of cure.

Extensive abdominal surgery is withstood well by children if particular attention is paid to multiple transfusion therapy in overcoming chronic anemia and weight loss. Chemotherapeutic agents, especially sulfasuxidine and sulfathaladine, have proved their worth as intestinal antiseptic agents. Parenteral penicillin seems to be useful in combatting infection in the wound and about the site of anastomosis.

Acute obstruction is always to be regarded as an emergency in itself. Early surgery should be directed only at intestinal decompression. Resection of the malignant growth should be done at a subsequent date.

#### SUMMARY

1. Forty-eight authentic cases of carcinoma of the large bowel, excluding rectum and rectosigmoid, in patients sixteen years of age and under are reviewed.

2. The importance of not under emphasizing the occurrence of carcinoma in young persons is stressed.

3. The symptomatology is essentially that of adults.

4. Colloid carcinoma is ten times more frequent in children than in adults. For this reason, palpable masses are commonly found.

5. Ignoring the so-called "cancer age" will effect earlier diagnosis and brighten the rather dismal prognosis by instituting earlier curative surgery.

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# PATHOLOGICAL AND PHYSIOLOGICAL CONSIDERATIONS IN ARTERIOVENOUS FISTULAS

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**A**LTHOUGH arteriovenous fistulas are uncommon they are not rarities. The traumas of both war and peace have supplied a rather clear understanding of the mechanism of production, as well as of the physiology and pathology of fistulous communications between arteries and veins. William Hunter first clearly defined an arteriovenous aneurysm as an abnormal communication between an artery and a vein and described its characteristic thrill and bruit. Breschet described two cases of arteriovenous fistulas treated by proximal ligation of the artery, which in each instance, was followed by gangrene of an extremity. Norris (1843) successfully treated a patient with this condition by ligation of the artery both proximal and distal to its venous communication.<sup>2</sup>

## CASE REPORT

**CASE I.** F. W. S., aged ten, was admitted to the Jewish Hospital, service of Dr. Samuel Goldberg, on February 25, 1946. The authors were called in consultation two days later. On November 19, 1945, an older brother placed a stick of dynamite in an artillery shell of World War I vintage and then threw it onto a coal stove. In the subsequent explosion, the patient received an injury to his left shoulder and arm. A swelling soon developed over the left shoulder and in the infraclavicular region, which subsided when the patient coughed and expelled some blood from the wound of entrance. The blood loss was described as "considerable." Two days later the left upper arm and later the left forearm began to swell. The child was then hospitalized and received tetanus antitoxin. He experienced two brisk hemorrhages from the wound and received three blood transfusions, the last one on December 23, 1945. Soon after injury, the left arm became discolored, being of a purplish-red hue, and the patient complained of a sensation of numbness in the left thumb and forefinger.

On examination, the patient was a well developed, somewhat pale and nervous child. He did not appear acutely ill and showed no evidence of cyanosis, jaundice, dyspnea or eruptions. The head and scalp, ears, eyes and nose were normal. The tonsils were hypertrophied, the anterior pillars being slightly injected. The neck showed a slight submaxillary adenopathy bilaterally. Over the left anterior chest above the second rib extending to the clavicle was a pulsating, expansile mass, 3 inches in diameter, over which a thrill could be felt. A bruit was present which was best heard just above the second rib, within the mid-clavicular line, and slightly cephalad to a  $\frac{3}{4}$  inch scar (the wound of entrance). The bruit was heard throughout the cardiac cycle but was accentuated during the systole. The mass was slightly tender but showed no change in color as compared to the opposite side or the surrounding skin.

The heart did not appear enlarged and the heart sounds were normal. The left shoulder, arm and forearm were moderately swollen and appeared somewhat dusky in color. There was marked venous engorgement of the left arm. Grossly, the left arm from the shoulder to the antecubital fossa showed an increased warmth, and the left forearm from the antecubital fossa to the tips of the fingers was much cooler than the opposite member. There was a definite weakness of the entire left upper extremity, both in flexion and in extension. No pulse was palpable in the axilla, antecubital fossa or the wrist, nor was a blood pressure obtainable in this extremity. The biceps and triceps reflexes were diminished on the left.

The blood pressure of the right arm was 124/70; that of both lower extremities 150/90. Oscillometric readings showed 5 to 6 in the right arm above the elbow,  $1\frac{1}{2}$  in the right forearm, 1 in the left arm and 0 in the left forearm. Skin temperature readings substantiated clinical impressions that there was an increase in the surface temperature from the left clavicle to the antecubital fossa and then a



decreased temperature from the antecubital fossa to the fingers. The venous pressure in the left arm was 260 mm. of blood, the right arm was 70 mm. Fluorescein studies showed a marked increase in collateral channels over the left shoulder.

The electrocardiogram was within normal limits. An x-ray taken on March 1, 1946, reported the presence of an opaque metallic foreign body in the soft tissue posterior and superior to the left humerus. There was also noted a poorly defined soft tissue mass in the left anterior hemithorax, extending toward the region of the left shoulder, with an irregular distortion of the soft tissue contours. Fluoroscopic study showed the heart to be slightly enlarged, particularly the left ventricle. The abdomen and genitals were normal.

Urinalysis was negative. On February 26, 1946, a blood count showed 12.5 Gm. hemoglobin, 4,320,000 red blood cells and 5,550 white blood cells per cu. mm. Of the latter, 42 were polymorphonuclear leukocytes (76 per cent filaments, 24 per cent non-filaments) and 58 per cent were lymphocytes. The preoperative diagnosis was that of an arteriovenous fistula of the subclavian artery and vein.

On March 12, 1946, under intratracheal ether anesthesia, supplemented by nitrous oxide and oxygen, Dr. Norman Rothschild made an incision from above the suprasternal notch on the left side, down to above the nipple and up the other side of the shoulder. This flap was dissected upward above the clavicle. The periosteum was incised, separated from the clavicle, and the clavicle was then removed and placed in a saline solution. The pectoralis major was reflected toward the midline and a large sac was uncovered; the pectoralis minor was then separated and retracted toward the outer side. All of the vessels entering or leaving the sac were ligated and cut including the subclavian artery and vein; the sac was then removed. The pectoralis major was repaired and the clavicle sutured into place.

Postoperatively, the patient received several whole blood transfusions and was placed on penicillin, 20,000 units every three hours, as a prophylactic measure. The entire course was most gratifying, the swelling of the left arm, forearm and hand subsided, and the temperature approximated that of the right upper extremity. An x-ray performed on March 27, 1946, revealed the absence of the previously

noted soft tissue shadow in the left upper hemithorax and the disappearance of the venous distortion of the soft tissue over the left shoulder. Fluoroscopic re-examination apparently indicated the return of the left ventricle to normal size.

#### COMMENTS

*Physiological.* An arteriovenous fistula introduces a secondary circuit into the vascular system.<sup>2</sup> With the development of such an abnormal connection, arterial blood pours directly into the vein, and in so doing chooses the path of least resistance as compared to the more highly resistant normal vascular bed of arterioles and capillaries which arterial blood ordinarily traverses. The capacious venous system thus becomes suddenly distended with blood drained from the arterial system and produces a situation equivalent in effect to a massive hemorrhage. As a result, the arterial blood pressure falls and an increased heart rate ensues. The venous pressure being elevated, a greater return of blood to the right side of the heart causes an increase in stroke output from the left ventricle. In this manner, the systolic pressure is gradually restored to its original level but the diastolic pressure remains low, the pulse pressure being thus elevated. Thus, the sequence of events from the time the fistula is first produced is a lowering of the blood pressure, a gradual restoration of the systolic, but not the diastolic pressure, and an elevation of both the pulse pressure and the pulse rate.

The deficit in blood volume in the arterial system as a result of the deviation of a considerable portion of the blood to the venous side, is compensated by an increase in blood volume.<sup>2</sup> However, much of this increased volume is again poured into the venous channels and thus in time this increase in the blood volume causes a dilatation of both the blood vessels and the heart.<sup>3</sup>

Holman<sup>4</sup> points out that the immediate effect of the diversion of blood from the arterial into the venous bed is a decrease

in the size of the heart. Later, in non-fatal fistulas, the lowered blood pressure is compensated by an increase in total blood volume and by a gradual dilatation of the heart and of the artery proximal to the fistula.

An arteriovenous fistula supplies a tremendous impetus to the formation of collateral vascular channels. This is believed to be the result of the very low pressure in the blood vessels in close proximity to the fistula. Soon, these events are followed by a dilatation of the whole vascular bed of the adventitious circuit. In part at least, this increase in vascular lumen results because the muscular and elastic coats of the participating artery undergo a form of degeneration which is thought to be due to the absence of the customary recoil of its walls. The adjacent vein at the same time enlarges and its walls thicken.

*Signs and Symptoms.* The symptoms and signs of an arteriovenous fistula are quite characteristic. Locally, an expansile mass is observed which pulsates and transmits a continuous bruit and thrill, both of which are accentuated during the cardiac systole. Numerous pulsating veins are present.<sup>3</sup> The involved extremity exhibits an increased skin temperature in the region of the fistula and somewhat beyond; as well as an increase in circumference (an arteriovenous fistula may be the cause of a so-called hemihypertrophy). More distal to this warm area, the affected member shows a marked decrease in surface temperature, as well as other trophic disturbances such as ulceration and necrosis.<sup>3</sup> Babcock has clearly described<sup>5</sup> the interference with the normal blood flow in arteriovenous fistulas. In systole, the arterial blood flows into the veins and interrupts the venous current. With diastole, the venous blood returns to, and frequently through the anastomosis to the artery. With the following systole, the admixture of arterial and venous blood is driven on to the distal capillary bed. It can be seen that the distal portion of the extremity suffers not only from lack of blood quantity but also because the blood

it receives is partly venous and partly arterial. Blood that is removed from the veins of an extremity, which is supplied with blood that has passed through an arteriovenous aneurysm, is classically rich in oxygen. The arterial blood supplying such a part is comparatively low in oxygen. Branham's bradycardiac reaction is a pathognomonic sign of an arteriovenous fistula. When digital pressure is made over the fistula so as to close it temporarily, the heart rate is slowed and the blood pressure rises.

A small fistula occasionally closes by spontaneous thrombosis and organization. A large fistula tends to become even larger, and cardiac decompensation with the presence of edema and effusions may follow the progressive development of the ill effects of such an abnormal opening.<sup>3</sup> However, this type of cardiovascular disease is often reversible, since with the closure of the fistula, its malignant effects on the heart and blood vessels quickly disappear. Mason<sup>6</sup> reported a case of arteriovenous aneurysm of the subclavian vessels, with an extreme degree of cardiac decompensation, which was completely corrected by ligation and excision of the fistula.

*Treatment.* Operative interference is the only promising method of treatment. The optimum operative period is considered to be three to six months after the formation of the aneurysm so that sufficient time may elapse in which absorption of the hematoma, subsidence of an infection which may have resulted from the injury, the establishment of an adequate collateral circulation and the possible spontaneous closure of the occasional small fistula may take place.

#### CONCLUSION

A case of an arteriovenous fistula involving the subclavian artery and vein is presented with a favorable result following surgical removal. A review of the physiology, pathology and diagnostic symp-

tomatology is set down. The radical removal of the aneurysm as soon as collateral channels have formed saves later irreversible cardiac damage. If this optimum time for radical treatment is adopted, seemingly irremediable heart damage may disappear.

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TUNNEL wounds in the neighbourhood of large arteries are the commonest cause of traumatic aneurysm. Swollen thighs, the result of haemorrhage, if kept at rest and watched carefully, slowly resume their normal size, providing there is a good circulation in the foot. When the swelling and bruising subside a pulsating mass with a bruit over it is apparent.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams & Wilkins Company).

# MULTIPLE INJURIES DUE TO TORNADO

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IN this mechanized age, patients with multiple injuries are not uncommon. This case is reported because of

and abrasions, their clothing had been torn from them, so that dirt and blood made them indescribably dirty.



FIG. 1. X-ray showing fracture in both femurs with plate applied and good union present.

its unusualness, severity and ultimate recovery.

## CASE REPORT

On January 6, 1946, the family of Mr. E. S., were seated at the supper table when a tornado struck. The house was totally demolished. Father, mother, four daughters and one son were swept across a corn field, anywhere from 300 yards to a quarter of a mile, by the wind. All were seriously injured.

One of the girls was found dead about a quarter of a mile from where the house stood. The mother died in about forty-five minutes after admission to the hospital. In addition to major injuries, all had innumerable small cuts



FIG. 2. This photo shows scars of the wounds in buttock and left thigh where femur protruded.

The son, M. S., aged twelve, was in a state of profound shock. He was pulseless, cold and clammy, with very weak respirations. He was first given 500 cc. of blood plasma, the only vein which we could quickly puncture being the jugular. The plasma was followed by 500 cc. of 10 per cent glucose. In about three hours he was given 500 cc. of citrated blood. During this preliminary treatment, he was cleaned up and the following found: A large depressed fracture of left frontal bone, compound comminuted fracture of both femurs, in the upper one-third of the left femur the bone protruding through the skin posteriorly. The right femur was fractured in the lower one-third, the bone protruding anteriorly. There were two large lacerated wounds of the buttocks. There was



FIG. 3. Photo shows scar of wound in head.



FIG. 4. Photo shows protrusion of brain through skull defect.

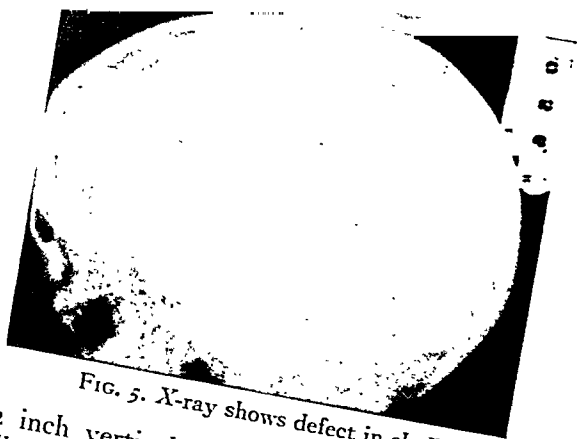


FIG. 5. X-ray shows defect in skull.



FIG. 6. X-ray showing tantalum plate in place.

a 2 inch vertical cut over the right eye. In addition to these, there were innumerable small cuts and abrasions.

By the next morning he had rallied sufficiently to be carried to the operating room, where a débridement of his wounds was done, with primary closure of the cuts. The fracture in the skull was 5 by 7 cm. in size. The dura was torn and there were several fragments of bone stuck into the brain. There was some loss of brain substance. The legs were put in traction. He was given tetanus-gas gangrene, combined anti-toxin.

On his return to his room, he was given 500 cc. citrated blood and started on penicillin,

20,000 units every three hours. All of the wounds became infected. Numerous checkings of the fractured femurs with x-ray, showed it was impossible to maintain good position. By January 31, 1946, the leg wounds were free from infection and open reduction was done. At operation, torn muscle was found interposed between the ends of the bones. This was removed and Vitallium plates were applied to each femur and a body cast applied.

The operative wounds healed without infection. The cast was removed in seven weeks. Good union with ample callous was evident from x-rays. Passive motion of the joints was started. The wound on the head healed slowly;

drainage persisted until March 5, 1946. When lying flat on the bed, there was considerable protrusion of the brain with marked pulsation. On being raised to a sitting position, the brain would retract. If this change was made suddenly, it was accompanied by nausea and as a rule the patient would vomit and would not be nauseated for the rest of the day. By April 15, 1946, the scalp wound had thoroughly healed and had been free from drainage for thirty days. At this time an inlay tantalum plate was applied and fastened with glazier points of tantalum.

As the scalp was closed, 200,000 units of penicillin in 10 cc. sterile water were injected into the wound. Under the scalp a small piece of Penrose drain was inserted. This drain was removed in forty-eight hours. In ten days the wound was perfectly healed, the sutures were out and the dressing was discarded.

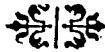
The scar in the scalp is within the hair line and the contour of the skull has been restored.

On May 1st, the patient was dismissed from the hospital and is now walking with the aid of



FIG. 7. Photo showing end result of operation upon head with restoration of the contour of skull.

a stick. To date there has been no evidence of mental disturbance.



# REGIONAL ILEITIS

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**R**EGIONAL ileitis was first described as a disease entity by Crohn, Ginzburg and Oppenheimer in 1932.<sup>1</sup> Since it has been recognized as such and reported more and more frequently. It is a destructive, inflammatory process usually beginning in the distal ileal segment of the small intestine, affecting young adults in most cases.<sup>2,3,4,5</sup>

## ETIOLOGY AND INCIDENCE

Various authors have been of the opinion that regional ileitis is caused by bacteria, bacterial toxins, viruses, protozoa, metazoa, non-specific inflammation of the appendix, achylia gastrica, allergy, foreign bodies, trauma, impairment of blood supply, interference with the lymphatic supply or heredity. In view of the above it is possible that the disease may be caused by "a number of heterogeneous primary irritating agents."<sup>2,4</sup> Felsen<sup>6</sup> believes that it is a manifestation of bacillary dysentery.

Regional ileitis is predominant in young people. Sex and race are not important factors. Fallis<sup>7</sup> reported thirty-two cases of regional ileitis, over 80 per cent of the patient being under forty years of age. The ratio of males to females was 4:3. Bockus, Johnson and Lee<sup>8</sup> reviewed nine cases of regional ileitis and found that the oldest patient was forty-three and the youngest eighteen years. There were four males and five females. Sneiderman and Ryan,<sup>4</sup> in a series of twenty-two cases, found thirteen males and nine females. Mayo and Judd,<sup>9</sup> in their series of 100 cases, found fifty-four males and forty-six females. The average age was 32.5 years.

## SYMPTOMATOLOGY AND DIAGNOSIS

The symptoms of regional ileitis vary according to the four stages of the disease.<sup>1,2,3,4,5</sup>

*Acute Stage.* The patient presents an acute abdomen simulating acute appendicitis. There is pain and tenderness in the right lower abdomen, fever, leukocytosis, nausea, vomiting and sometimes a palpable mass. Diarrhea alternating with constipation may be present. At operation, the involved portion of the intestine and its mesentery are soggy, thickened, edematous and reddened. The mesentery also contains enlarged nodes. Although the appendix usually appears to be uninvolved in the inflammatory process, it may sometimes become diseased, and even form an abscess.

*Ulcerative Stage.* In this type of case, the patient complains of colicky abdominal pain and intermittent diarrhea, the stools sometimes containing mucus and blood. Accompanying symptoms are malaise, weight loss, secondary anemia, and as the disease progresses, loss of strength. Intermittent low grade fever may also be present.

*Obstructive Stage.* At times, the first indication of this disease may be incomplete intestinal obstruction. However, this stage usually follows the ulcerative stage and is due to the thickening of the walls of the intestine with resultant narrowing and stenosis of the lumen of the intestines. The outstanding symptoms are severe abdominal cramps (temporarily relieved by passage of stool), horborygmus and visible peristalsis. A mass may be palpated in the right lower abdomen and intermittent vomiting may also be present.

*Fistula Forming Stage.* This is a late stage of the disease and is due to slow perforation of the ulcers or it may follow drainage of an intra-abdominal abscess. These fistulas do not heal spontaneously and usually persist despite attempted operative closure. They may be internal, joining the involved portion of the ileum

to any of the other abdominal viscera; or they may connect with the abdominal wall along the scars of previous operations. When such a fistula appears following an appendectomy it is practically diagnostic of the disease. Perirectal abscess and perianal fistulas may also accompany this condition.

The diagnosis is confirmed by the following roentgenologic findings: (1) Constant filling defect in the affected portion of the intestine. (2) loops of small bowel proximal to the filling defect may be irregular in shape. In the presence of obstruction, there is dilatation of these loops. (3) There may be a thin, irregular, string-like shadow in the region of the filling defect ("string-sign" of Kantor<sup>11</sup>) which is thinned out barium filling the narrowed intestinal lumen.

Regional ileitis must be differentiated from the following conditions which present a similar symptomatology, and often, a similar gross appearance at operation: neoplasms of the intestines, tuberculosis of the intestines, ulcerative colitis, actinomycosis, syphilis of the intestines, Hodgkin's disease and appendicitis (the latter condition is very rarely associated with diarrhea). The final diagnosis is made either by x-ray findings or at operation.

#### PATHOLOGY

In the acute stage the involved segment of the intestine and its mesentery are thickened, edematous and reddened, and the mesentery contains hyperplastic lymph glands. The serosa is mottled red. Mucosal ulcerations may also be present. There may be some free serous fluid in the peritoneal cavity. Microscopically, the mucosal ulcerations may be covered with a fibrinopurulent exudate. There is acute inflammatory reaction in the intestinal wall. The subserosa is edematous, congested and hemorrhagic.<sup>2</sup>

In the later stages of the disease the bowel becomes thick, firm and rigid. There may be areas of normal bowel between sharply defined diseased segments.<sup>4</sup> There

is a tendency toward perforation with accompanying formation of adhesions to the surrounding viscera. Usually, perforation into the peritoneal cavity does not occur. Fistulization then occurs with occasional abscess formation in the mesentery. The lumen of the intestine is markedly constricted and distorted, sometimes becoming obliterated. The serosa is thickened and fibrotic and sometimes has small tubercle-like lesions on its surface.

Histologically, there is hypertrophy of the muscular layer as well as inflammatory involvement of the submucosa, muscularis and subserosa with fibrosis. The entire mucosa may be eroded or only the surface epithelium may be missing. Irregular ulcerations are seen lined by granulation tissue containing many neutrophils. There may also be zones of atrophy of the mucosa and other areas of polypoid hyperplasia. Granulation tissue, containing nodules and frequently foreign body giant cells, is seen throughout the muscularis and subserosa.<sup>4</sup>

#### TREATMENT

There are three schools of thought concerning the treatment of regional ileitis.

*Conservative Management.* This consists of exploratory laparotomy without disturbing the intestines, or exploratory laparotomy and appendectomy (the latter being an incidental procedure and not contributing to the spontaneous resolution of the disease). This type of treatment is recommended for the acute stage and in those cases which are too far advanced for radical surgery. If symptoms persist, a radical operation may then be performed when the patient can be better prepared for this type of procedure.<sup>2</sup>

Cutler<sup>12</sup> believes he can get good results without any surgery except when obstruction or abscess is present. His regimen consists of a bland, high-protein, high-vitamin and low-residue diet. Mineral oil, transfusions, bed rest and alpine light should be used as indicated. X-ray therapy may help in some cases. Recently, it has been suggested that streptomycin is specific for



regional ileitis. However, the results are not as yet conclusive.

**Short-circuiting Operation.** In the chronic stages of the disease, surgical treatment is indicated. Some writers believe that a short-circuiting operation (ileocolostomy) should be done first, especially if the patient is in poor physical condition. However, this procedure has been comparatively ineffective.<sup>2,8</sup> In most cases, the disease progresses despite this procedure, with resection being necessary at a later date. Many authors believe that this procedure is insufficient because it leaves the diseased bowel behind as a focus of infection.<sup>3</sup> Fallis, in his cases, reported two deaths of three patients treated by entero-anastomosis. There were no deaths in his series of patients treated conservatively or by radical resection.

**Radical Resection.** Wide resection of the diseased intestine (depending upon the extent of lymphadenopathy) with anastomosis of ileum and transverse colon, is the treatment of choice in the chronic stage of regional ileitis. It has been effective in a majority of the cases in which this procedure was done.<sup>2</sup> Some writers recommend a two-stage resection because of less risk to the patient, while others<sup>8</sup> believe that a one-stage resection should be done wherever possible, because of a reduced mortality and because the possibility of recurrence is less than when a two-stage resection is done.

Mayo and Judd<sup>9</sup> reported the results of resection in 100 patients with non-specific ileocolitis. There were seven deaths among thirty-two patients treated by one-stage resection (21.9 per cent); and two deaths among sixty-four patients treated by two-stage resection (3 per cent). Four had operations in multiple stages and there was one death in this group.

Eckel and Ogilvie<sup>13</sup> state "... that if improvement or a cure is to be anticipated in the patients with a chronic condition, a truly radical resection of bowel and mesentery must be done."

Warren and Miller<sup>14</sup> state that in their

series of forty-three cases, conservative treatment in early cases gave good results. Surgical resection yielded satisfactory results in only eight out of twenty-six cases. However, they stress that "since conservative treatment of the established disease . . . gives little hope of cure, radical resection should still be offered these patients as the initial procedure."

Colp, Garlock and Ginzburg<sup>15</sup> report forty cases of regional ileitis treated by ileocolostomy with exclusion. There were no postoperative mortalities in their cases and they state that extension of the disease proximally apparently does not depend upon the type of operation performed but rather on how far oral the site of exclusion is chosen.

Ginzburg and Garlock<sup>16</sup> are convinced that distal ileitis is a surgical disease and that marked improvement may be obtained in most cases by ileocolostomy with exclusion which, in their experience, has been attended by no mortality. Ashley, Meyers and Reynolds,<sup>17</sup> on the other hand, think that regional enterocolitis is "not entirely a surgical problem, since 25 per cent of our cases, after an early diagnosis, show no extension of the disease under judicious medical management and observation." They advocate radical resection, in stages, as the treatment of choice for the advanced cases.

Marshall,<sup>18</sup> reviewing the experience with this disease at the Lahey clinic, urges that complete extirpation of affected bowel be done, wherever possible, with wide removal of involved mesenteric glands. At the Lahey clinic, the two-stage Mikulicz type of resection is favored, and they believe that it can be used in serious cases with a low operative risk.

#### CASE REPORT

P. H., a seventy-eight year old white male, was admitted to the Norwegian Hospital on July 8, 1945, complaining of pain in the right lower quadrant of the abdomen and nausea of four to five days' duration. The pain had begun in the left lower quadrant and then settled in

the right lower quadrant. The pains had been very severe for the last three days. Nausea was present all that time, but no vomiting. There had been no bowel movements since the onset of the present illness. Patient had had arthritis and "some heart trouble" about fifteen years ago. A hydrocelectomy had been performed sixty years ago.

Physical examination revealed a well developed and well nourished elderly white male complaining of severe pain in the right lower quadrant of the abdomen. The lungs were clear and resonant throughout. There was a blowing systolic murmur at the apex. The apex beat was 2 cm. lateral to the mid-clavicular line; there was regular sinus rhythm. There was marked tenderness in the right lower quadrant of the abdomen with rebound, rigidity and tenderness in the left lower quadrant. The blood count revealed 18,000 white blood cells with 88 per cent polymorphonuclears. The pre-operative impression was acute suppurative appendicitis with peritonitis and intestinal obstruction.

Operation was performed on the day of admission under spinal anesthesia. A large McBurney incision about 5 inches long was made. About 6 inches of ileum, 6 inches from the ileocecal junction, was markedly edematous and thickened, markedly inflamed and covered with a thin fibrinous exudate in many areas. There was very little to no lumen apparent. There were many small lymph nodes in the mesentery which was greatly thickened and fibrotic to palpation. The appendix was seen to be slightly involved in the inflammatory process, but was certainly not the cause of the peritonitis. The cecum was slightly injected as were the terminal 6 inches of ileum. The entire ileum was explored for other segments of involvement, but no pathological condition was noted except for a generalized distention of relatively mild character in practically the entire ileum.

It was decided not to remove the appendix. A portion of ileum about  $2\frac{1}{2}$  inches on either side of the involved portion was resected by cautery and a classical aseptic end-to-end anastomosis by means of Kocher clamps was performed. Eight Gm. of sulfanilamide were sprinkled over the operative area. One Penrose drain was placed to the right iliac fossa and one to the pelvis. Postoperative diagnosis was regional ileitis and peritonitis.

The pathological report was as follows: The specimen consisted of small intestine measuring 28 cm. in length, presenting somewhat irregular brownish-red surface. There was flakey, whitish exudate over the entire outersurface. Mesentery attached to the bowel was infiltrated with much fatty tissue and also covered with the same exudate. The mesentery was markedly thickened and indurated in many areas. The serosa of the bowel was rough and irregular. Upon opening the bowel, there were no contents found. The mucosa was apparently normal and present along the entire length. The submucosa was markedly thickened and cord-like in consistency. The lumen of the bowel presented two constrictions at which points the lumen was decreased to one-third of its size. The entire specimen may be compared with a portion of rubber garden hose.

Microscopically, examination showed marked congestion of all coats of intestine with scattered inflammatory cell infiltrations. Attached mesentery also showed marked inflammatory reaction. There was marked fibrosis of muscular coats and serosa.

Diagnosis: Regional ileitis—terminal ileum.

Post-operatively, the patient did comparatively well for one week and then developed a bilateral bronchopneumonia. Pneumonia was treated with penicillin, sulfadiazine and oxygen. Despite this and with rigid maintenance of fluid balance, electrolyte balance, adequate vitamins and adequate protein levels by means of two whole blood transfusions, two units of plasma and adequate amino acid administration, the patient's course continued downhill. He went into cardiac failure and finally expired on July 26, 1945, eighteen days postoperatively.

The writer is certain that this man, although 78 years of age, would have withstood the surgical procedure successfully if he had not contracted bilateral pneumonia and thrown an added load on a previously damaged and enlarged heart.

#### SUMMARY

A brief review of regional ileitis, covering incidence, etiology, pathology, symptomatology and diagnosis is presented.

Treatment and management is stressed calling attention to the conservative, short-

circuiting and more radical surgical measures of resection.

The case of a seventy-eight year old male is reported (probably a report of the oldest patient on record).

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# POSTOPERATIVE SPONTANEOUS PNEUMOPERITONEUM

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THE presence of air in the peritoneal cavity is to be expected in any condition in which excess of air is allowed by injury or perforation of the intestinal tract or when the peritoneum is opened as in surgical or traumatic conditions. Under modern conditions, this has also been used in the Rubin test and in peritoneoscopy as well as in the introduction of air or other gases for therapeutic or diagnostic reasons. Aside from the symptoms due to the immediate introduction of the air with its accompanying changes in pressure, this is unimportant as the air is absorbed within a comparatively short space of time. The presence of air is also found in peritonitis due to gas forming organisms.

Gas or air in the peritoneal cavity without demonstrable reason and in sufficient amounts to cause symptoms is rare. This condition, called "spontaneous pneumoperitoneum," has been recorded five times previously according to the literature available to the writer. Hinkel<sup>1</sup> summed up the literature to date in an admirable paper and also gave in detail the known etiology and pathology of the condition. He states: "The intra-abdominal pressure is nearly always negative (Wagoner) and, according to Salkin, it may reach 50 mm. of water below that of the atmosphere. The introduction of fluid or air into the peritoneal cavity does not raise the pressure sharply because of the 'abdominal accommodation' described by Coombs. Therefore, if air should enter through an aperture in the diaphragm, one could not expect it to be expelled through the same route unless the intra-abdominal pressure became greater than that of the atmosphere." Thus, the presence of air due to perforations of the intestinal tract or from

openings to the atmosphere, would be in sufficient amounts to equalize the pressure between the peritoneum and the external source and would not be progressive. According to this idea, the presence of a distention which was sufficient to cause symptoms and progressive enough in nature would almost have to be connected in some way with the bronchial tree, barring gas-forming organisms or repeated perforations. The mechanism involved would be essentially the same as that in tension pneumothorax, the lungs being the only pump-like mechanism sufficient to produce the extreme pressure developed in the peritoneal cavity. We assume this condition was caused by a tear through the diaphragm into the bronchial tree, plus a ball-valve mechanism of the diaphragm.

The following case of spontaneous pneumoperitoneum is the first of its kind to be reported in a patient following a surgical procedure in which the symptoms were so alarming as to constitute a serious factor in an otherwise normal convalescence. It corresponds with four of the five cases previously reported, in that there was an accompanying chest condition which could be explained on the basis of the mechanism noted above (Hinkel). The fifth recorded Rigler,<sup>2</sup> was the only one in which the symptoms were due to some intestinal condition. Since perforation of the intestinal tract with the appearance of air is common and since these are often found only at autopsy or at operation, this case (Rigler) while undoubtedly spontaneous pneumoperitoneum, might very well have been due to some perforation. In his patient also the symptoms were not progressive and the presence of air was not in sufficient amount to cause serious symptoms.



FIG. 1. X-ray showing subdiaphragmatic collection of air.

#### CASE REPORT

CASE 1. D. Y., aged fifty-one, was admitted to Our Lady of Lourdes Hospital because of bilateral inguinal hernias of thirty years' duration. The patient has been well, aside from influenza in 1918 of three weeks' duration which was followed by a chronic bronchitis with attacks of what was diagnosed as bronchial asthma at infrequent intervals. There was no history of intestinal disturbances; his bowels were regular; he ate everything and used tobacco and alcohol moderately. He had always been an out-of-doors man and the only reason he was being operated upon was that he noted that he tired more easily especially when he was out hunting or fishing.

At operation, done under spinal anesthesia, the hernias were repaired by the Bassini technic without difficulty. The patient's condition was good through the procedure and he was returned to his room in excellent condition. fluids were allowed immediately after operation and penicillin was started at once. The bowels moved with an enema on the third postoperative day and the patient was eating well. Convalescence was uneventful until on the fifth postoperative day, when following an enema, the patient complained of moderate abdominal pain and a slight chill. His temperature rose to 102°F.; the abdomen became distended but not alarmingly so. He did not vomit and was not nauseated. At this time the wounds were healed and his temperature had been normal for two days. He also complained

of a certain amount of chest distress and had a severe coughing spell. The following day the distention was much more pronounced; however, he was taking liquids well and he stated that he felt fine. An enema was given and returned with a moderate amount of gas and some liquid stool; the distention, however, remained constant. His condition remained the same until the next day when the distention was so severe as to cause respiratory embarrassment. He was placed in an oxygen tent, but there was no improvement. During this entire period he had no complaints aside from a feeling of distention. He had no more coughing spells; he was taking liquids well and enemas were returned with what was considered fair results. The distention, however, reached the point where the abdomen was almost board-like to the touch; there was a tympanitic note on percussion. X-ray examination revealed the picture seen in Figure 1. A diagnosis of pneumoperitoneum of unknown origin was made and under 1 per cent novocaine a needle was inserted into the peritoneum at the left upper quadrant and 3,000 cc. of air was removed with immediate relief. Air was under such pressure as to force the glass plunger out of a dry 100 cc. syringe. Suction was not necessary at any time during the procedure. The following morning the distention had increased from what it had been immediately after the tapping but not to a comparable degree with that seen before. He was again tapped with a trocar and an unmeasured amount of air was withdrawn. A positive pressure was purposely left in order to prevent possible vascular symptoms due to the sudden intra-abdominally change. Further tapplings were not used and the abdomen over a period of ten days gradually became softer until at the time of discharge it was practically normal. At no time other than the initial insult was there an elevation in temperature. The patient sat on the edge of the bed on the fifth day following the last tapping; he was out of bed on the sixth day and was discharged four days later. To date, April 20, 1946, the patient has been perfectly well and has carried on his normal pursuits and states that he feels stronger than he has in years.

#### SUMMARY

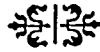
A case of spontaneous pneumoperitoneum (the sixth) is reported. This is

similar to four of the other cases in which there is an accompanying chest condition. This case is unusual in that it followed an operative procedure with opening of the peritoneum but at such a late date that there could be no connection between this and the pathological condition present. It also parallels the picture of tension pneumothorax in that the condition became worse and also was relieved only by removal of the air. The presence of a connection between the bronchial tree and the peritoneum seems necessary, in view of the fact that at no time either before or after the operation were there any symptoms

referable to the gastrointestinal tract. Also, as is seen in tension pneumothorax, the release of the air resulted in a breaking of the vicious cycle and spontaneous recovery. Subsidence occurred spontaneously after removal of part of the air.

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THAT blast injury to the lungs is present should be suspected when there are diminished movements of the diaphragm, fullness of the chest, giving it an emphysematous appearance, and impairment of resonance at one or both bases. It is usual to find the lower chest ballooned, especially in the region of the lower costal margin.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams & Wilkins Company).

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# Selected Book Reviews

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THIS is not a paragraph of book reviews. Just consider that we are tipping you off to a few books published during the past year that are very worth while. No one physician wants a fraction of the medical books published each year. But every progressive physician must have a library of scientific works, especially in his field of practice. So, should you wish a certain book on a subject of interest to you, we recommend any one of the following:

*Muscle Testing—Techniques of Manual Examination.* By Lucille Daniels, M.A., Marian Williams, M.A. and Catherine Worthingham, M.A. Designed and Illustrated by Harold Black with 349 Diagrammatic Line Drawings. 189 pages. W. B. Saunders Company.

*A Textbook of Gynecology.* By Arthur Hale Curtis, M.D. 5th Edition with 455 illustrations, chiefly by Tom Jones, including 36 in color. W. B. Saunders Company.

*Physical Chemistry of the Cells and Tissues.* By Rudolf Höber with the collaboration of David I. Hitchcock, J. B. Bateman, David R. Goddard, and Wallace O. Fenn. 676 pages and indexed. The Blakiston Company. (The last word on this subject to date.)

*Urgent Surgery.* (Vol. 1). Edited by Julius L. Spivack, M.D., LL.D. Eight surgeons present operative technics they employ in the type of cases requiring immediate or almost immediate intervention. 244 figures having 572 illustrations, 14 in color. Charles C. Thomas.

*Diagnosis and Treatment of Menstrual Disorders and Sterility.* By Charles Mazer

and S. Leon Israel. Second Edition, Revised and enlarged, with 133 illustrations. Paul B. Hoeber, Inc.

*Pathology in Surgery.* By Nathan Chandler Foot, A.B., M.D. This book meets the needs of the pathologist, surgeon, intern and student. 368 illustrations in black and white and 20 subjects in full color on 10 plates. J. B. Lippincott Company.

*Classic Descriptions of Disease.* By Ralph H. Major, M.D. 3rd. Ed. Beautifully printed, 195 Authors, 287 Selections, 158 Illustrations. (Just the gift for a young physician.) Charles C. Thomas.

*General and Plastic Surgery with Emphasis on War Injuries.* By J. Eastman Sheehan, M.D. Timely—authoritative. Paul B. Hoeber, Inc.

*Human Embryology.* By Bradley M. Patten, with 1,366 drawings and photographs, 53 in color. A textbook. The Blakiston Company.

*Anesthesia in General Practice.* By Stuart C. Cullen, M.D. Illustrated. The Year Book Publishers, Inc. (We highly recommend the Year Books of the various specialties published each year.)

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*Gynecological and Obstetrical Pathology.* With Clinical and Endocrine Relations. By Emil Novak, A.B., M.D., D.Sc. (Hon. Dublin), F.A.C.S. 2nd Edition with 542 Illustrations, 15 in color. W. B. Saunders Company.

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